Types and Characteristics of Food Additives and Their Impacts on Human Health

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Abstract. Given how frequently food additives are used in the food industry today, questions have been raised regarding how they affect human health and the environment. The impact of food additives on the environment and human health are examined in this paper. By preventing microbial growth and oxidation processes, food preservatives and antioxidants increase the shelf life of foods, guarantee their safety, and maintain their quality. Whether made naturally or chemically, food colourants give colour stability to guarantee uniform food look. Although there are problems, notably with regard to the potential carcinogenicity of saccharin, sweeteners provide a choice for enhancing sweetness with chemical stability and minimal calories. Food stabilisers and coagulants enhance mouthfeel, prevent component separation, and improve texture and stability. Whether natural, like the polyphenols in tea and ascorbic acid, or artificial, like BHA and BHT, antioxidants prevent the oxidation of lipids and dietary ingredients. Food additives raise health issues like allergies and cancer risks despite governmental control. By 2023, the World Health Organization wants to completely ban trans fats from industrial production. To guarantee customer safety and high-quality products, China implements strict rules through the Food Safety Law that includes the manufacturing, importation, use, and management of food additives.

Keywords: Food additives, health effects, food safety, food industry, food regulations.

1. Introduction

Although food is an essential aspect of everyone's lives, food additives are frequently utilised in food processing as a key part of the food industry. As the food business has grown, more and more food additives have been created for a variety of uses, such as flavour, colour, and preservation. The manufacturing of food now depends heavily on food additives. People's worries about the possible effects of food additives on the environment and health have grown as their use has increased. At the same time, more and more people are becoming aware of the health risks connected to food additives and asking a lot of questions. This paper aims to investigate the effects of various food additive kinds on human health.

2. Common Food Additives and Their Functions

2.1. Food preservative

Food preservatives are chemicals or natural ingredients that are added to food to limit the growth of germs, increase shelf life, and stop food from decaying or degrading [1]. To prevent contamination during storage and transit, food preservatives are frequently added to food or beverages. They assist in extending the shelf life of food, minimising waste, and making sure no health concerns are present when it is consumed.

2.1.1. Nitrite preservatives

Nitrite preservatives, mainly including sodium nitrite ($NaNO_2$) and potassium nitrite (KNO_2), can stop the development of bacteria, parasites, and other microorganisms, protect food degradation and spoilage (oxidation processes), and improve shelf life. Preservatives containing $NaNO_2$ can also stop food's lipids and proteins from oxidising.

Nitrite preservatives' antioxidant capabilities allow them to prevent or at least delay oxidation reactions, maintaining food's flavour, freshness, and appearance. Additionally, animal proteins can react with nitrite preservatives to produce a pink molecule that gives meat its distinctive hue [2]. Additionally, nitrite preservatives can contribute to the distinctive flavor of smoked meat products when they react with other compounds.

2.1.2. Potassium sorbate

Potassium sorbate (C6H7KO2) is an organic acid preservative. It is a colorless crystalline powder that is odorless or has a faint odor, and is found naturally in many other plants, including goji berries, strawberries, and apples. By preventing microbial growth, it increases the shelf life of food. It means that potassium sorbate could interfere with their metabolic processes, bacteria, yeast, and other microorganisms are inhibited and food shelf life is increased [3]. It is noted that the taste and nutritional value of the food are not harmed throughout the preservation process.

2.1.3. Parahydroxybenzoates

Methylparaben (C8H8O3) is a preservative belonging to the parahydroxybenzoates class. It is a white or colourless crystalline powder, odourless or with a faint, distinguishing odour. Its melting point is between 125 and 128°C. Methylparaben works as a preservative by preventing bacteria' cells from producing respiratory and electron transport enzymes. It achieves the preservation effect by destabilising the bacteria' cell membrane structure, which causes protein denaturation within the cells. It has a broad range of antibacterial activity against different fungi, such as moulds and yeasts.

2.1.4. Acetaldehyde

Acetaldehyde (C8H8O4) is also an organic acid preservative. It is an odourless, colourless, or white crystalline powder [4]. Strong antibacterial qualities make acetaldehyde effective against mould and yeast. It is categorised as an acidic preservative and is essentially useless in foods that aren't acidic. Acetaldehyde has a preservation function by preventing the growth and reproduction of bacteria, yeast, and moulds.

2.2. Food Coloring

Food dye, usually referred to as food colouring, is a chemical frequently used to give food colour and enhance its look. In the food sector, food colouring is frequently used by food producers to alter the colour of their goods and guarantee consistency across all batches.

2.2.1. Artificial Colorants

There are many types of synthetic colorants added to food, typically derived from chemicals such as aniline, toluene, naphthalene. Common synthetic food colorants include Allura Red (Red No. 40 - E124), Amaranth (Red No. 2 - E180), Tartrazine (Yellow No. 5 - E102), Sunset Yellow (Yellow No. 6 - E110), Erythrosine (Red No. 3 - E127), and Brilliant Blue (Blue No. 1 - E133). Synthetic colorants exhibit high stability under food processing conditions, making them resistant to fading or decomposition during cooking, storage, and transportation.

2.2.2. Natural Colorants

There are numerous kinds of naturally occurring colourants as well, the most of which are taken from plants, animals, vegetables, and fruits. Carotenoids are typical natural yellow and orange pigments that are often taken from plants like carrots and pumpkins, with β-carotene being the most well-known. Beet red, a red colour used in beverages and sweets, is made from beetroot. The green colour found in plants is called chlorophyll, and it is occasionally added to mint sweets and green fruit juices. Red pigment known as cochineal red is taken from the bodies of cochineal insects and used as culinary colouring. When red yeast is fermented, a red pigment called red yeast rice is created.

2.3. Food Sweeteners

Food sweeteners are additives that are added to foods to increase their sweetness. They can be used in place of or in addition to conventional sugars. Natural sweeteners are the most suited and effective source of energy and play a significant part in human nutrition. Sweeteners can improve the flavour of food by adjusting, balancing, and masking any off-putting flavours.

2.3.1. Natural Sweeteners

Usually, natural sweeteners are derived from plants or animals. There are numerous widely used natural sweeteners, such as honey, which is produced by bees from the nectar of flowers. Many foods and beverages, such as bread, sauces, and desserts, use honey. Another popular natural sweetener is maple syrup, which is made from the sap of maple trees. Waffles are a common dessert that uses it. A sweetener made from birch trees called xylitol is occasionally added to snacks like chewing gum. Xylitol is a sweet-tasting white crystalline substance. Its caloric content is comparable to that of glucose; however, it has little impact on insulin levels and may even increase insulin secretion. As a result, it is regarded as the best sugar alternative for those who have diabetes.

2.3.2. Artificial sweeteners

Synthetic sweeteners have the advantages of having relatively stable chemical characteristics, being resistant to heat, acid, and alkali, and being less prone to decomposition. They can be used for many different things. Additionally, artificial sweeteners frequently do not contribute to the body's metabolism. After consumption, the majority of sweeteners are eliminated from the body without calories. This qualifies them for use by those with diabetes, as well as by the elderly or obese people. Aspartame is a popular low-calorie artificial sweetener that is used in low-calorie and sugar-free beverages. Its sweetness is comparable to sucrose. Another widely used sweetener is saccharin; however, it is prohibited in several nations because it may be cancer-causing and linked to the growth of tumours [5]. Since saccharin has a sweetness that is similar to sugar, it can increase food sweetness without resulting in fermentation or colouring during processing.

2.4. Food Stabilizers and Coagulants

Food stabilisers are frequently employed to enhance the stability, structure, and texture of food. They can maintain the homogeneity of the food by preventing the separation and settling of food ingredients. They also improve the viscosity, gelation, and fluffiness of food to enhance the food texture and mouthfeel. In some coagulants, free ions such as calcium, magnesium, hydrogen ions, or charged ion groups are present in the form of molecule. These have the potential to damage protein solutions' colloidal stable double-layer structure, causing precipitates or gels to develop.

2.4.1. α-cyclodextrin

α-cyclodextrin is a white powder with no specific odor and a slightly sweet taste. It is a product of enzymatic conversion of starch syrup by glucosyltransferase. A-cyclodextrin can be used as a stabilizer, aiding in the stability of colorants and flavors in various food products. It prevents decomposition and enhances and improves the structure of food, preserving and optimizing its flavor. A-cyclodextrin can also eliminate specific odors; it can capture and mask undesirable odors and tastes in food.

2.4.2. Xanthan gum

The powder form of xanthan gum is white or light yellow. It can make food viscous and more substantial, which enhances the mouthfeel and texture of the dish. Fruit and chocolate beverages can benefit from the addition of xanthan gum by tasting better and developing a richer mouthfeel and pleasant scent. Ice crystal formation is minimized by xanthan gum's exceptional stability throughout repeated freezing and melting procedures. Additionally, it may maintain the uniform distribution of various food ingredients, avoiding precipitation and separation.

2.4.3. Calcium Chloride

Calcium chloride is a tasteless, somewhat bitter material that is white, hard, lumpy, and crystalline. It is often used to increase the meal's hardness and improve the mouthfeel and texture of the food, particularly for fruits, vegetables, and tofu. Certain foods, such frozen goods and jams, can benefit from calcium chloride's ability to keep their form and structure, preventing them from shifting during storage and transportation. Additionally, it might increase the juiciness of food. Calcium chloride in the brewing of beer can impact the wort's acidity and the effectiveness of the yeast, resulting in the sweetness of the beer. In some cases, calcium chloride is also included in sports drinks as an electrolyte.

2.5. Food antioxidants

Food antioxidants can stop or inhibit the oxidation or deterioration of lipids, oils, and other food constituents as well as the oxidation of these substances. Water-soluble antioxidants and fat-soluble antioxidants are the two main categories of food antioxidants. Since they can stop the oxidation of lipids and some nutrients during manufacturing, transit, and storage, which can result in changes in flavour or spoilage, fat-soluble antioxidants are excellent for foods with a high-fat content. In order to lessen or completely remove browning brought on by oxidation, water-soluble antioxidants are frequently added in the preparation of fruits and vegetables. Regarding processing and starting ingredients, food antioxidants can also be divided into natural antioxidants and synthetic antioxidants.

2.5.1. Tea polyphenols

The polyphenolic compounds known as tea polyphenols have a significant role in the composition of tea leaves. They also provide the human body with a number of possible health advantages. The majority of the phenolic chemicals known as tea polyphenols may be found in the tea leaf. One class of tea polyphenol renowned for its astringent flavour is catechins. Strong antioxidant qualities are exhibited by tea polyphenols, which can assist in scavenging free radicals to lessen oxidative stress and cell deterioration [6]. Tea polyphenols are used in a variety of items, such as beverages with plant-based proteins, fried snacks, meat products that have been marinated, and canned seafood. They are regarded as safe for intake because they are natural antioxidants. The antioxidant activity of tea polyphenols is enhanced at higher temperatures, making them highly suitable for incorporation into various food products.

2.5.2. Ascorbic acid

Vitamin C, usually referred to as ascorbic acid, is a common antioxidant found in diet. It has a sour flavour, and is an odourless, white or light-yellow crystalline powder [7]. When exposed to sunshine, it eventually turns brown. Ascorbic acid is prone to oxidation into dehydroascorbic acid because it is highly stable in dry environments and has reducing characteristics. It is found in abundance in many fresh fruits and vegetables, such as lemons, grapefruits, kiwis, strawberries, tomatoes, red peppers, and more. Ascorbic acid can delay the oxidation of lipids, retaining the colour and flavour of the food when added to fats or fruits. Additionally, it is utilised in beverages to eliminate oxygen and stop flavour and colour alterations.

3. Potential Effects of Food Additives on Health

Due to the increasing usage of food additives in the food business, more and more individuals are becoming aware of their potential health effects. Nowadays, almost all foods, such as snacks, drinks, quick noodles, chewing gum, jelly, and bread, contain chemicals to some degree. Many individuals are nevertheless concerned about the possible risks of food additives, although the majority of them are introduced in line with rules and are subject to regulatory inspection.

However, food additives have the potential to cause a wide range of health problems, such as allergies, high blood pressure, diabetes, cancer, and metabolic difficulties [8]. All of these health issues may be exacerbated by food additives. An example of a food additive is food colouring, which

has been linked to health issues in certain people such as diarrhoea and allergic responses [9]. Additionally, several dietary additives such as hydrogenated vegetable oil, margarine, shortening, puff pastry margarine, and non-dairy creamer contain trans fats. Low-density lipoprotein (LDL) cholesterol levels have been shown to significantly rise and high-density lipoprotein (HDL) cholesterol levels to significantly decline when trans fats are consumed. Breast cancer, colorectal cancer, stomach cancer, and other cancers may also be influenced by them.

The World Health Organization (WHO) set a 2023 deadline for removing industrially generated trans fats from the world's food supply [9]. In order to reassure consumers and allay their health worries, an increasing number of food products are now labelled and promoted as having "0 trans fats." The health effects of other preservatives, such as sodium benzoate, nitrites, and benzoic acid, are also possible. Additionally, several dietary additives, such as hydrogenated vegetable oil, margarine, shortening, puff pastry margarine, and non-dairy creamer, contain trans fats. Sodium benzoate, for instance, readily reacts in the stomach to form benzoic acid, and prolonged consumption can lead to benzoic acid poisoning. It may also result in neurological issues like nervousness and headaches [9].

4. Food Regulations and Oversight in China

On June 1, 2009, China started enforcing the "Food Safety Law of the People's Republic of China," in response to worries about the potential health dangers connected to specific food additives [10]. The production, importation, usage, and management of food additives are all covered by this regulation in eight separate categories. China has also built a system for assessing the risks to food safety and assigned officials to handle risk evaluations. The usage of the mandatory national standards for food additive products. The law specifies obligations and the consequences for breaking them. The permitted levels of food additives must not exceed the established thresholds under China's rigorous rules. Every batch of food produced is sampled, tested, and periodically inspected by representatives of the Market Supervision Administration. These actions highlight how crucial food safety is in China.

5. Conclusion

By preventing microbial growth and oxidation processes, food preservatives such as potassium sorbate, acetaldehyde, and nitrite preservatives serve a critical role in preserving the quality of food and extending its shelf life. They maintain flavour and appearance while ensuring food safety during storage and transit. Carotenoids, beetroot red, and chlorophyll are examples of naturally occurring food colourants. Food colourants are substances used to change the colour and appearance of food. During food preparation, they demonstrate exceptional stability, preventing fading or breakdown and providing uniform product colour. Whether they are natural, like honey and maple syrup, or artificial, like aspartame and saccharin, food sweeteners provide options to increase sweetness and satisfy a variety of dietary requirements. These additives have minimal calories and stable chemical features, yet certain areas continue to worry that saccharin may be carcinogenic. Utilizing food stabilisers and coagulants improves the mouthfeel of the food by increasing viscosity, gelation, and fluffiness while avoiding ingredient separation and precipitation. Examples include calcium chloride, xanthan gum, and α-cyclodextrin, each of which performs a particular task in the production of food. Food antioxidants are essential for halting the oxidation of lipids and food constituents. Antioxidants that are fat-soluble shield foods heavy in fat against contamination, while antioxidants that are water-soluble shield fruits and vegetables from fading. Ascorbic acid (vitamin C), which is utilised in beverages to maintain flavour and colour, and tea polyphenols like catechins, which prevent lipid oxidation and colour changes in fruits, are examples of natural antioxidants. Various food additives may have possible consequences on human health, according to research on the connection between food additives and health. While certain additives are healthy for humans when used in moderation,

others, such as those for youngsters and those with allergies, may pose health hazards. The significance and complexity of food additives are emphasized in this study. Future investigations could go further into the health risks of particular chemicals, enhance testing methods, and create stronger regulatory standards. In conclusion, this study provides important knowledge for future research and the formulation of public policy as well as a better understanding of the connection between food additives and health.

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