MODERN APPROACHES IN AGRICULTURE AND ALLIED DISCIPLINES

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Preface

Sustainable food production is essential for addressing global challenges such as climate change, food security, and environmental degradation. With the world population projected to reach 9.7 billion by 2050, ensuring a steady food supply without exhausting natural resources is a critical priority. Traditional agricultural practices contribute to deforestation, soil degradation, excessive water usage, and greenhouse gas emissions, making the transition to sustainable methods imperative.

The importance of sustainable food production lies in its ability to balance productivity with environmental preservation. By adopting eco-friendly farming techniques such as organic farming, crop rotation, agroforestry, and precision agriculture, we can reduce chemical dependency, enhance soil fertility and optimize resource use. Additionally, sustainable practices help mitigate climate change by reducing carbon footprints and conserving biodiversity. Urbanization has led to innovative solutions like vertical farming, hydroponics, and aquaponics, which maximize space efficiency and minimize water consumption. The future scope of sustainable food production is expansive, driven by technological advancements and shifting consumer preferences. Smart farming, powered by artificial intelligence the Internet of Things (IoT), and big data analytics, is revolutionizing agriculture by improving efficiency, monitoring soil health, and predicting crop yields. Lab-grown meat and plant-based protein alternatives are also emerging as sustainable solutions to reduce the environmental impact of traditional livestock farming. Policy reforms and global initiatives, such as the United Nations' Sustainable Development Goals (SDGs), are accelerating the adoption of sustainable agriculture. Governments and organizations worldwide are investing in research, innovation, and farmer education to promote responsible food production practices. In conclusion, sustainable food production is not just a necessity but a transformative shift towards a healthier planet and future generations. By embracing sustainable techniques and emerging technologies, we can ensure a resilient food system that meets the demands of a growing population while safeguarding natural resources.

-Authors

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Chapter 24

Food Additives and Contaminants

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Food Additives

In a modern food industry, there are more than 2,500 chemical substances which are intentionally addedto foods in small amounts on a daily basis to enhance its color, flavor, stability, texture, shelf life, taste and to reduce its cost. Moreover, around 12,000 substances may unintentionally enter the food chain through packaging materials, processing agents, pesticide residues, or even drugs given to animals. An unknown number of naturally occurring chemical contaminants can also find their way into food. While many substances may accidently enter our food supply chain, others are deliberately added for specific purposes, and these substances are known as food additives (Wu et al., 2021).

Definitions

"*Food additives are substances intentionally added to food in small quantities to improve its safety, preservation, sensory appeal, or technological(including organoleptic) functions. These additives do not serve nutritional purposes, though some may indirectly affect health or metabolism.*"

While natural food contains no additives, as foods are processed for conversion into a variety of products, an increasing number of additives are generally used (Branen et al., 2002).

WHO2018) also defines, "*Food additives as the substances which are added to foods to improve or maintain the taste, texture, appearance, safety, or freshness of foods.*"

According to Codex Alimentarius (2021), the term "food additive" does not include contaminants or any substance added to food for maintaining or enhancing its nutritional qualities.

Food additive means any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be reasonably expected to result (directly or indirectly), in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods.

The term does not include contaminants or substances added to food for maintaining or improving nutritional qualities. Approval for their use is granted only after thorough evaluation and confirmation of safety by food safety authorities. This can only be granted after the FDA approves that the

manufacturer has submitted sufficient toxicological data to demonstrate that the additive is safe for human consumption (Wu et al., 2021).

Food additives not only function in food preservation, but also help in enhancing food color, shelf life, flavor, flexibility, as well as the nutritional value of food. Proper food additives can be added to make up nutrition loss during food processing. They are effective against malnutrition, nutrient deficiency and promote nutrition balance (Wiley and Nee, 2020).
The key characteristics of food additives are as follows:

- Intentional (unlike contaminants)
- Trace amounts
- Technological or sensory function
- Strictly regulated

Food additives currently in use are added to food as nutrients, colorants, emulsifiers, flavors or preservatives. Preservatives play a significant role in preventing the growth of yeast, molds and bacteria in foods. Colorants help in adding or restoring color to food, to enhance its visual appeal. Emulsifiers help mix ingredients like oil and water that normally do not blend. Food additives as nutrients help in enriching the food with essential vitamins and minerals to improve its nutritional value. Additionaly, flavorings in food enhances its taste and aroma (Wu et al., 2021).

The use of most food additives has visible beneficial results in improving public health and in the prevention of spoilage, which eventually leads to enhanced food supply. However, there are afew controversies over the use of some common food additives, partly due to some individuals' hypersensitivity and allergic reactions toexposure to these chemical additives. Additionally, some individuals also believe that low levels of chronic toxicities and diseases might be caused in larger population by exposures to some of these chemical substances. These adverse reactions are often influenced by the chemical composition and the source of the additives used. Understanding the nature of these substances is essential, as their origin-whether they are natural or synthetic, can play a significant role in how the body responds to them (Wu et al., 2021; Alemu et al., 2022).

Food additives are intensively used and provide functions in improving food quality. However, the vast majority of food safety incidents caused by illegal activities, especially the abuse and illegal use of food additives have caught public concern worldwide. Therefore, the regulation and measurement of food additives are two most effective methods to standardize the market action and enhance the level of food safety. To better understand the practical role of food additives (both beneficial and potentially harmful), it is beneficial to understand their specific uses, types and how they appear on food product labels. Categorizing these additives with the real-world examples allow us to better understand their roles and the reasons behind their widespread use in our everyday foods.

The following tables gives a detailed illustration of different types of food additives, including their uses, examples, purpose and the name under which they are typically listed in the table no. 1.

Table 1: Uses of different food additives (Chinaza et al., 2020).

Type of ingredients	Typical examples ofUses	Purpose	Names seen on product labels
Color Additives	Many processed foods such as candies, cheese, pie fillings, soft drinks, jellies, jams, snack foods margarine, gelatins, and pudding	• Offset color loss as a result of exposure to temperature extremes, light, air, moisture and storage conditions • Enhancecolors that occurnaturally; • Correctnatural variations in color; provide color to the colorless and fun foods	FD&C* Green No. 3, FD&C Blue Nos. 1 and 2, FD&C Red Nos. 3 and 40, FD&C Yellow Nos. 5 and 6, Citrus Red No. 2, Orange B, annatto extract, cochineal extract or carmine, beta-carotene, grape skin extract, paprika oleoresin, caramel color, saffron, fruit and vegetable juices
Flavor Enhancers	Many processedfoods	Enhance flavors already present in food (not providing their own separate flavor)	Monosodium glutamate (MSG), autolyzed yeast extract, hydrolyzed soy protein, disodium guanylate or inosinate
Fat Replacers	Baked goods, frozen desserts, confections, dressings, dairy products, cake and dessert mixes	Provide expected texture and creamy mouth-feel in the reduced-fat foods	Olestra, polydextrose, modified food starch, cellulose gel, carrageenan, guar gum, xanthan gum, microparticulated egg white protein, whey protein concentrate
Flavors and Spices	Gelatin dessert mixes, pudding and pie fillings, cake mixes, candies, soft drinks, ice cream, salad dressings, BBQ sauce	Add specific flavors(Both natural and synthetic)	Natural flavoring, spices, and artificial flavor
Preservatives	Fruit sauces and jellies, baked goods, cured meats,	• Prevent food spoilage from molds, fungi, bacteria, or yeast (antimicrobials); • Maintain freshness;	Ascorbic acid, citric acid, calcium propionate, sodium erythorbate, sodium benzoate,sodium

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	beverages, oils and margarines, dressings, Snack foods, cereals, fruits and vegetables	• Prevent or slow changes in color,texture, or flavor, anddelayrancidity(antioxidants)	nitrite, calcium sorbate, BHA, BHT, EDTA, potassium sorbate, tocopherols (Vitamin E)
Sweeteners	Beverages, baked goods, table-top sugar, confections, substitutes, many processed foods	Add sweetness with or without extra calories	Sucrose (sugar), fructose, glucose, sorbitol, mannitol, high fructose corn syrup, sucralose, corn syrup, saccharin, aspartame, neotame, acesulfame potassium (acesulfame-K)

***Note: In FD&C, the FD&C stands for: F = Food; D = Drug &C = Cosmetic; Therefore together, FD&C means the color is approved by the U.S. FDA (Food and Drug Administration) for use in foods, drugs, and cosmetics.**

While some reports suggest a possible link between monosodium glutamate and the worsening of asthma or onset of headaches, leading international health and scientific organizations,including the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the World Health Organization (WHO), the American Medical Association (AMA), the European Community's Scientific Committee for Food (ECSCF) and the National Academy of Sciences (NAS), have concluded that MSG is safe for consumption at typical dietary levels (Chinaza et al., 2020).

Table 2: Food additives and their uses (Chinaza et al., 2020).

Typesof ingredients	**Typical examples of uses**	**Purpose**	**Names seen on product labels**
Anti-cakingAgents	Salt,confectioner'ssugar, baking powder	Prevent absorption,moisturekeep powdered foods free-flowing	Calcium silicate, silicon dioxide, iron ammonium citrate
Dough strengthenersand conditioners	Breads, otherbaked goods	Produce more stableDough	L-cysteine, ammonium sulfate, azodicarbonamide
Emulsifiers	Salad dressings,peanut butter, margarine, chocolate, frozen desserts	Allow smooth mixing of ingredients, avoid separation, keep emulsified products stable, control crystallization, keepingredientsdisperse	Soy lecithin, egg yolks, polysorbates, mono- and diglycerides,Sorbitan monostearate

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		d,help products dissolve more easily, reduce stickiness	
Enzymepreparations	Cheese, dairyproducts, meat Enzymes, papain, lactase, rennet, chymosin	Modify proteins, fats,and polysaccharides	
FirmingAgents	Processed fruitsand vegetables	Maintain firmness and crispness	Calcium chloride,calcium lactate
Gases	Oil cooking spray, carbonated beverages, whipped cream	Serve as propellant,create or aeratecarbonation	Carbon dioxide,nitrous oxide
Humectants	Shredded coconut, Soft candies, confections, marshmallows	Retain moisture	Glycerin, sorbitol
Leavening agents	Breads, other baked goods	Promote rising of the baked goods	Baking soda, calcium carbonate, monocalcium phosphate
Nutrients	Flour, cereals, rice, macaroni, breads, margarine, salt,milk, energy bars, instant breakfast drinks, fruit beverages	Replace micronutrients(vitamins andminerals), lost during processing, (enrichment), add thenutrients which may belacking in(fortification)	Thiamine hydrochloride, niacin, niacinamide, folate or folic acid, riboflavin (Vitamin B2), Vitamin D, beta carotene, iron or ferrous sulfate, potassium iodide, alpha tocopherols, ascorbic acid, amino acids (L-lysine, L-leucine, L-tryptophan, L-methionine)
pH Controlagents and acidulants	Beverages, chocolate, low-acid canned foods, frozen desserts, bakingpowder	Control acidity and alkalinity, prevent spoilage	Citric acid, lactic acid, Ammonium hydroxide, sodium carbonate
Stabilizers, thickeners, texturizers, binders	Frozen desserts, dairy products, pudding andgelatin mixes, cakes,	Produce uniform texture, improve the mouth-feel	Gelatin, guar gum, carrageenan, pectin, xanthan gum, whey

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	dressings, jams, jellies,sauces		
Yeast nutrients	Breads, other baked goods	Promote growth of yeast	Ammonium phosphate,calciu msulfate

Numbering system of Food Additives

For the information and regulation of food additives are classified and assigned by unique numb3ers in different countries. The numbering method in European Union gives each food additive a unique number called "E number", which is used in Europe for all approved additives. Similarly, to how E numbers are used in Europe, INS (International Numbering System) numbers are used in India.

E numbers and INS numbers system are used to identify food additives which are used in the processing and preparation of different food products. These codes provide a standardized method to label food additives and allow consumers to be informed about what substances are present in the food they are consuming (Gowrishankar, 2023).

E numbers

E numbers are a system of codes used in the European Union (EU) to identify food additives. The “E” stands for “Europe” and these numbers were established by the European Food Safety Authority (EFSA) and the European Commission.The E number system was introduced to harmonize the use of food additives across the EU member states and to ensure that only safe and approved additives are used in food products.

Food additives with E numbers include preservatives, antioxidants, flavor enhancers, colorings, emulsifiers, stabilizers, thickeners, and more. The examples of E numbers and their permitted uses is defined in the EU Regulation (EC) No 1333/2008, which specifies the types and maximum levels of additives that can be used in various food categories.

Table 3: E number and INS number of food additives (Gowrishankar, 2023).

Food Additives	E numbers	INS numbers
Colours	E100–E199	0-199
Preservatives	E200–E299	200-299
Antioxidants, Acidity regulators	E300–E399	300-399
Thickeners, Stabilisers, Emulsifiers	E400–E499	400-499
Acidity regulators, Anti-caking agents	E500–E599	500-599
Flavour enhancer	E600–E699	600-699
Antibiotics	E700–E799	700-799

INS Numbers

INS numbers stand for “International Numbering System,” are used by the Codex Alimentarius Commission. The Codex Alimentarius is a joint program of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), established to develop food standards, guidelines, and related texts.The INS numbering system was created to provide a global standard for identifying

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food additives, ensuring consistency in labelling worldwide.Similarly, to E numbers, INS numbers represent different food additives with specific roles in food processing and preparation.The E numbers and INS numbers are given in the table.

These numbers serve as identifiers on product labels, helping consumers and regulators recognize the substance used in the product. The E numbering scheme has now been adopted and extended by the Codex Alimentarius Commission to internationally identify all additives, regardless of whether they are approved for use. Using this method, the additives can be easily classified into groups that have different functions(Codex Alimentarius Commission, 2021).

Regulatory Bodies for Food Additives

There are various regulating bodies that analyze what must be added to food and food supplements and the quantities that they must be added so they will not have harmful effects on the consumer's health. These materials are termed as generally recognized as safe (GRAS). These regulations are used and approve thelabel declaration for substances as labeling of synthetic color and mixture of colors in food, Food additives not to be false description, Food additives to bear certain information, Processing aids and carry-over of food additives, Prohibition against sale of food containing non-permitted food additive, Conditions for a request to add to or change food additive, Restriction on sale, of baby foods containing food additive, Conditions for allowing more than one preservative, Ionizing radiation. Some of the penalties. In the U.S., food substances may either be FDA-approved food additives or generally recognized as safe (GRAS). Food packaging manufacturers must approve to the U.S. Food and Drug Administration (FDA) that all materials coming in tact with food are safe, before they are permitted for use in such a manner. Food additives were first subjected to regulation in the United States under the Food and Drug Act of1906 (Haley and Lyn, 2010; Badenhorst, 2014; FDA, 2018).

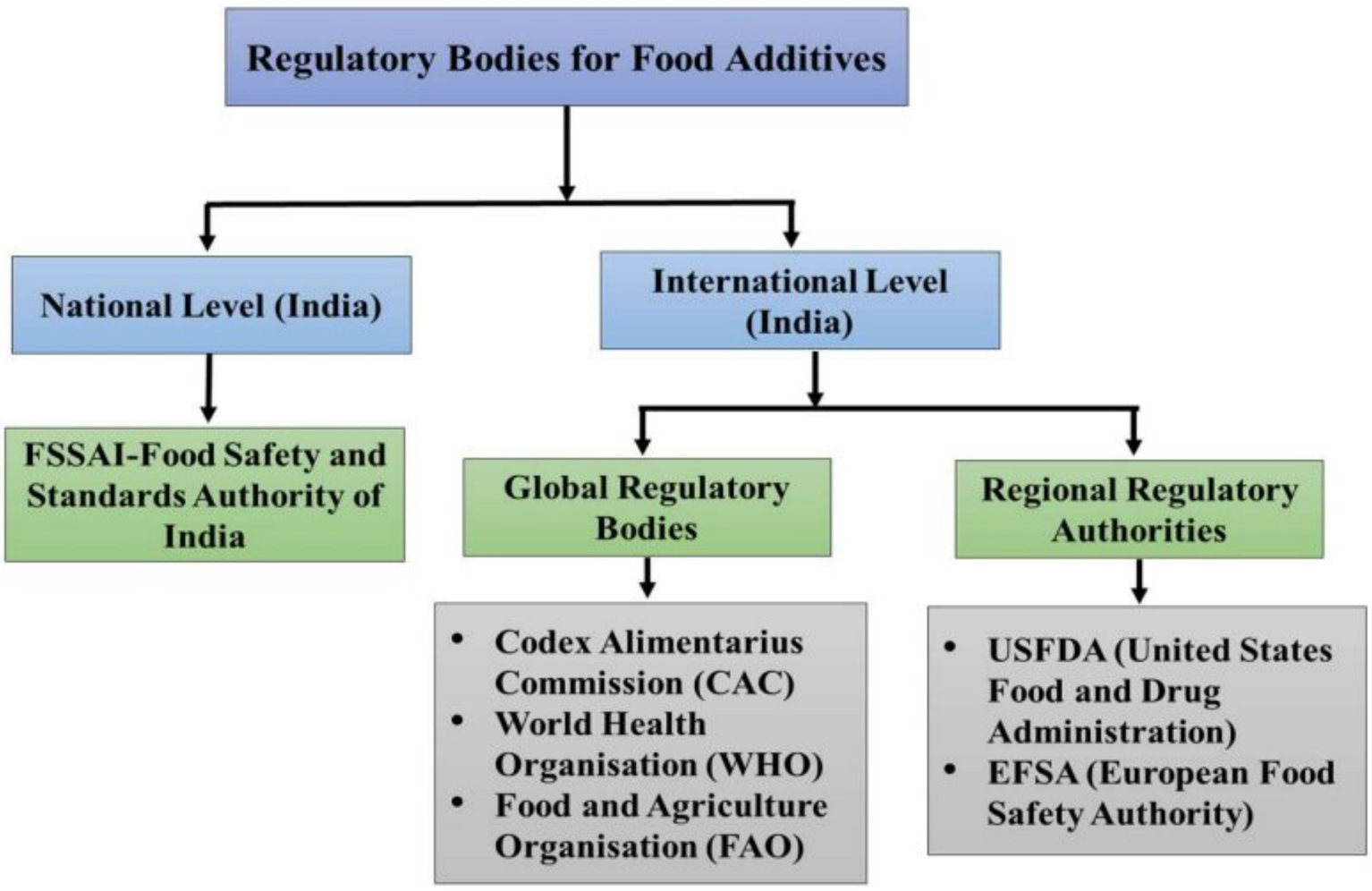

Figure 1: Regulatory bodies for food additives.

In India, the use of food additives is regulated by the Food Safety and Standards Authority of India (FSSAI). Whereas globally, various regulatory bodies, including the United States Food and Drug Administration (USFDA), the European Food Safety Authority (EFSA), and the Codex Alimentarius Commission, play crucial roles in formulating standards and safeguarding the use of food additives. The WHO, along with others, helps shape international food safety policies and standards, including those governing food additives.

TYPES OF ADDITIVES

There are thousands of food additives currently in use, all of which are designed to do specific function in making food safer, more nutritious, more appealing and to last longer (Chinaza et al., 2020).According to the compositions, food additives are generally divided into two major categories of natural and synthetic food additives. Food additives can be derived from animals, plants, or minerals, or can be synthetic (WHO, 2018).At present, artificial synthetic food additives have gradually replaced the natural ones. However, this shift has also led to several concerns, including the misuse of food derivatives, overuse of certain additives, and even the inclusion of harmful substances. While food additives do enhance sensory appeal of the food, they may also pose potential risks to human health(Wu et al., 2021).To address these concerns, food safety authorities globally have implemented strict regulations, requiring thorough safety assessments before additives are approved for use by humans. Understanding the distinction between natural and synthetic food additives is to better understand their importance and application, food additives are broadly grouped according to the purpose they serve in food systems.

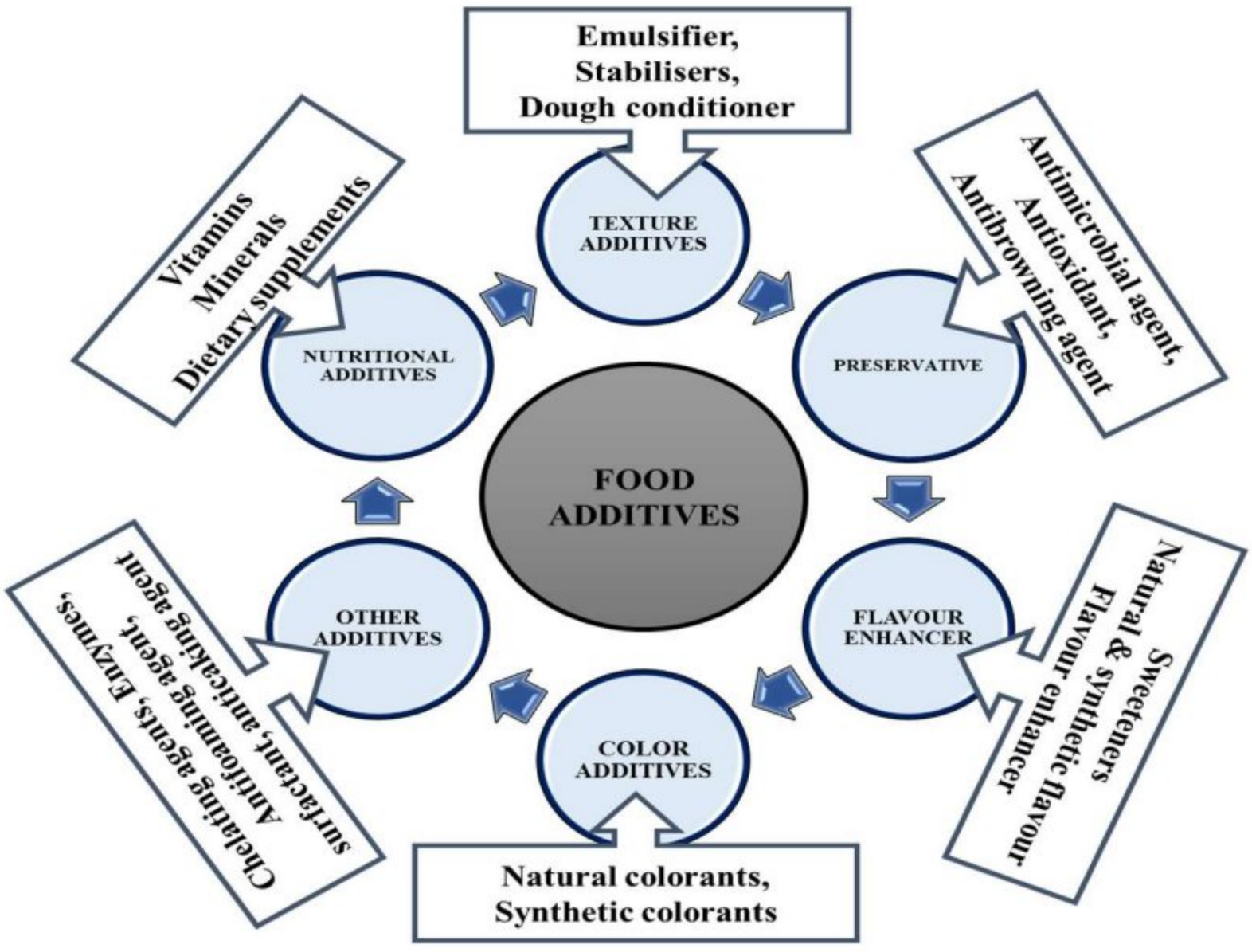

Figure 2: Types of food additives.

Colorants

Colorants are a kind of additives that are incorporated into food to restore lost color during processing, improve flavor perception, or enhance visual appeal (Coultate and Blackburn, 2018). Colorants used in food are both natural and synthetic, where natural food colors refer to naturally available dyes that are from vegetables, animals or minerals.For example, curcumin is primarily used to add color to foods such as beverages, sauces, and sweets, which can be added only lower than 0.01 g/kg. Canthaxanthin, commonly used to color tanning supplements, sweets, and carbonated beverages, is restricted to a maximum dose of 0.001 to 0.03 g/kg. On the other side, synthetic food colors, commonly referred to as artificial food colors are made through chemical processes. For example, quinoline yellow, which is often used in cold desserts like ice creams, sweets, and beverages, should be carefully regulated and kept below 0.1 g/kg in food products. Similarly, tartrazine, a colorant commonly added to soups, gums, ice creams, sweets, and mustard-flavored yogurt, has a recommended usage limit ranging between 0.015 to 0.018 g/kg(Wu.et al., 2021).

Preservatives

Preservatives are added to food to slow down spoilage from microbes like bacteria and fungi, ensuring it remain safe and fresh for a longer duration. Similar to food colors, preservatives can also be divided into two main groups of artificial and natural ones. Sorbic acid is one of the most widely used artificial preservatives in dairy products, soybean products, processed vegetables, cooked meat products and aquatic products. Its allowable concentration ranges from 0.075 to 2.0 g/kg in food processing. Similarly, benzoic acid and its salts, are another most commonly used preservatives in condiments, pickled products, beverage products and fruit wine, with its maximum amount ranging from 0.2 to 2.0 g/kg. Nisin, one of the natural preservatives is added to meat, dairy products, vegetable protein products, canned goods, coffee beverage, tea and soy sauce with its additive amount ranging from 0.15 to 0.5 g/kg. Moreover, the maximum dosage of natamycin should be controlled lower than 0.1 g/kg in food processing (Carocho et al., 2018).

Antioxidants

Antioxidants function primarily mainly inhibiting or slowing down the oxidation process, thus protecting the food from spoilage. Natural antioxidant additives are often used in food like meat, fish, fruits, nuts, vegetables, beverages and cannedfood. For instance, the quantity of ascorbic acid aswell as its salt form ascorbate and its geometric isomersshould be regulated within the range of 0.2 to 5.0 g/kg. The artificial antioxidants are often added to oils, cheese, and chips to suppress the formation of hydroperoxides. For instance, the phenol derivatives ofpropyl gallate should be controlled in dosage from 0.1 to0.4 g/kg. Moreover, tert-butyl hydroquinone (TBHQ) has the maximum dosage of 0.2 g/kg; and butyl hydroxyanisole (BHA) shouldbe used in a controlled range lower than 0.2 g/kg too (Carocho et al., 2018; Lorenzo et al., 2018).

Sweetener

Sweetener, is a class of food additive, which is used as a sugar substitute, containing significantly less food energy, making it a zero-calorie or low-calorie sweetener. Natural sweeteners like sorbitol, xylitol, and mannitol are derived from sugars, which are widely used in dairy products, tea products, alcoholic drinks, seasonings, candy, starch products, processed fruits and vegetables. Wherein, the

maximum dosage of sorbitol is from 0.5 to 3.0 g/kg; the additive amount of mannitol should be controlled under 0.2 g/kg. Artificial sweetener such as aspartame, cyclamate, saccharin sodium and sucralose are Glazing agents, flavor, desserts and dairy products. The maximum dosage of aspartame is from 0.3 to 4.0 g/kg; cyclamate has maximum dosage from 0.65 to 8.0; and saccharin sodium is from 0.15 to 5.0 g/kg (Martyn et al. 2018). Obesity epidemic is a global health problem which has caused wide attention recently, and low-calorie foods with sweet taste are favored by the individuals of all ages. Thus, low and no-calorie sweeteners with similar sweet taste as sugar has played a critical part in food industry. Wherein, artificial sweeteners like acesulfame (E950), aspartame (E951), cyclamate (E952), saccharin (E954), sucralose (E955) and neotame (E961) are non-caloric replacements used to enhance sweet tastes for food (Wu et al., 2021).

Emulsifiers, stabilizers, thickeners and gelling agents

Since many functions of food additives are overlapped, and thickeners and gelling agents have nearly the same functions (Abid et al., 2018). Therefore, emulsifiers, stabilizers, thickeners and gelling agents are categorized as one group from E400 to E499 in the E-number classification. Emulsifiers, also called emulgents, act as an interface between the conflicting components in water and oil (McClements and Jafari, 2018), and are used in creams and sauces, bakery, and dairy products. Examples of emulsifiers are polyglycerol esters, which has the maximum dosage range from 5 to 10 g/kg.

Stabilizers are substances or chemi- cals that allow food ingredients, which do not mix well, to remain in a homogenous state after blending (Tekin et al., 2018). The common food stabilizer includes agar, alginic acid and its sodium, potassium, ammonium and calcium salts. Thickeners or thickening agents are substances added to food preparations for increasing their viscosity without changing other properties like taste, for example, pectin has the maximum dosage of lower than 3.0 g/kg. Gelling agents like konjac, karaya gum, and gellan gum are incorporated into foods to produce specific structure, flow, stability and eating qualities desirable for consumers. Stabilizers and thickeners compounds function to enhance and stabilize the texture of foods, inhibit crystallization (sugar, ice), stabilize emulsions and foams, reduce the stickiness of icings on baked products, and encapsulate flavours. Substances used as stabilizers and thickeners are polysaccharides, such as gum Arabic, carrageenan, agar-agar, alginic acids, starch and its derivatives, carboxyl methylcellulose and pectin. Gelatin is one no carbohydrate material used extensively for this purpose. Stabilizers and thickeners are hydrophilic and are dispersed in solution as colloids. These swell in hot or even cold water and help thicken food. Thickeners are added to the mixture; increase its viscosity without substantially modifying its other properties (Coppens,2006; Alemu et al., 2022).

Glazing agents, flavor enhancer

Other additives like glazing agents which fall into this category, have other functions for improving whipping, leavening and color permanence (Teixeira, 2018). One glazing agent called shellac has the maximum dosage range of lower than 0.2 g/kg in food processing. Additionally, the food flavor enhancers like monosodium glutamate and guanylic acid function in enhancing the existing flavor, where monosodium glutamate has the maximum dosage from 0.2 to 0.5 g/kg and guanylic acid should be lower than 0.5 g/kg (Abdel-Moemin et al., 2018).

Table 4: Typical Representation of food additives with E-number, INS number and its uses (Abdel-Moemin et al., 2018; Lorenzo et al., 2018; Chinaza et al., 2020; Wu et al., 2021; Alemu et al., 2022).

Food Additives	E-Number		INS Number	Common Uses in Food
Colorants				
Natural Food Color	Natural carotene	E160a	INS No.160a(ii	Dairy products, frozen drinks, processed fruits, dried vegetables and soybean products
	Canthaxanthin	E161g	INS No.161g	Tanning pills, fruit-spreads, candies, syrups, sauces, carbonated drinks
	Curcumin	E100	INS No.100(i)	Beverages, sauces and confectionery
	Anthocyanins	E163	INS No.163	Jams, sugar confectioneries, jellies, soft drinks and frozen products
Artificial Food Colour	Quinoline yellow	E104	INS No.104	Cold fruits, ice creams, cake, chocolate, bread, cheese sauces and beverage products etc.
	Tartrazine	E102	INS No. 102	Soups, sauces, ice creams, sweets, chewing gum, marzipan, jam, jelly, marmalade and mustard yogurt etc.
	Sunset yellow FCF	E110	INS No. 110	Jam, dairy products, cocoa products, starch desserts, compound condiments, beverage products
	Carmoisine	E122	INS No. 122	Beverage, wine, candy, green plum, bayberry, sandwich, ice cream etc.
	Ponceau 4R	E124	INS No. 124	Beverage, wine, soda, candy, pastry, soya drink, ice cream, yogurt
	Allura red	E129	INS No. 129	Candy coating, fried chicken, meat enema, western ham, jelly, biscuit sandwich
Preservatives				
Natural Preservatives	Nisin	E234	INS No. 234	Meat, dairy products, vegetable protein products, canned goods, coffee beverage, tea, soy sauce
	Natamycin	E235	INS No. 235	Yogurt, cheese, raw ham, dried sausage, cakes

	Lysozyme	E1105	INS No. 1105	Cheese, drink, baby food, meat and fish products
Artificial Preservatives	Sorbic acid and potassium sorbate	E200	INS No. 202	Dairy products, soybean products, processed vegetables, cooked meat products, aquatic products, etc.
	Benzoic acid and Sodium benzoate	E210 E211	INS No.210 INS No. 211	Condiments, pickled products, beverage products, condiments, pickled products, beverage products, fruit wine
	Ethyl p-hydroxybenzoate Sodium ethyl p-hydroxybenzoate	E214 **E215**	INS No. 1014 INS No. 1015	Jam and sauce products, carbonated drinks, etc.
	Sodium nitrite ()	E250	INS No. 250	Soybean products, meat products, aquatic products, pastry and puffed foods.
	Propionic acid and sodium propionate	E280 E281	INS No. 280 INS No. 281	Soybean products, wet flour products, bread, pastry, vinegar and soy sauce.
Antioxidants				
Natural Antioxidants	Ascorbic acid and its salts	E300-302	INS No. 300-302	Peeled fresh fruits and vegetables, wheat flour, fruits and vegetables products
	Tocopherol and its geometric isomers	E306-309	INS No. 307 (a, b and c)	Meat, fish, nuts, vegetables, fruits, beverages and canned food
Artificial Antioxidants	Propyl gallate	E310	INS No. 310	Nuts and canned seeds, gum-based candy, grilled meat, fried noodles, etc.
	Tert-butyl hydroquinone	E319	INS No. 319	Moon cakes, instant rice noodles products, biscuits, baked food fillings
	Butyl hydroxyanisole	E320	INS No. 320	Fat, oil and emulsified fat products, coarse grain, instant rice noodles products, etc.
	Butylated hydroxytoluene	E321	INS No. 321	Fried noodles, gum-based candy, air-dried aquatic products, etc.
Sweeteners				

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Natural Sweeteners	Sorbitol	E420	INS No. 420(i)	Dairy products, jams, wet flour products, baked products, beverages and soybean products, etc.
	Mannitol	E421	INS No. 421	Candy, chewing gum
	Thaumatin	E957	INS No. 957	Candied fruits, candy, biscuits, canned meat, etc.
	Stevioside	E960	INS No. 960	Flavour fermented milk, candy, condiments, canned fruits, flavoured syrup and tea products
	Maltitol, maltitol sirup	E965	INS No. 965(i); 965(ii)	Processing fruits, frozen surimi products, soybean products, etc.
	Lactitol	E966	INS No. 966	Dairy products, Spices
	Xylitol	E967	INS No. 967	Dairy products, tea products, alcoholic drinks, seasonings, starch products, processed fruits and vegetables, etc.
Artificial Sweeteners	Aspartame	E951	INS No. 951	Dairy products, frozen fruits and vegetables, cereals and starch desserts
	Cyclamate	E952	INS No. 952	Canned fruits, jams, mixed wine, instant noodle food and condiments
	Saccharin and its salts	E954	INS No. 954(i); 954(ii); 954(iii)	Frozen drinks, dehydrated mango, dried figs, cold fruits, cooked beans and dried fruits
	Sucralose	E955	INS No. 955	Prepared dairy products, jams, sufu, coarse cereals products, baked products, etc
	Neotame	E961	INS No. 961	Dairy products, frozen fruits and vegetables, cereals and starch desserts
Emulsifiers, Stabilizers, Thickners				
Emulsifier, Thickners and Stabilizers	Polyglycerol esters	E475	INS No. 475	Soy milk drinks, ice-creams, spreads, breads, cakes, toffee, chocolate
	Sorbitan esters	E491-495	INS No. 491-495	Milk, ice-creams, breads, cakes, biscuits, soya products, dried yeast, drinks
	Sodium alginic acid	E400	INS No. 401	Milk products, cheese, margarine, freezing drinks

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	Agar	E406	INS No. 406	Ice cream, low-fat spreads, dairy products, salad dressings, mayonnaise
	Pectin	E440	INS No. 440	Jam, jelly, cheese, candy, sauce, yoghurt
	Gellan gum	E418	INS No. 418	Pudding, jelly, sugar, drinks, dairy products, jam products, bread
Flavour Enhancer				
	Monosodium glutamate	E621	INS No. 621	Soup, sausage, fish cake, chili sauce, canned food, puffed food, jelly
	Guanylic acid	E626	INS No. 626	Meat, ham, bacon, soy sauce, food condiments
Glazing agents				
Natural waxes or glazing agent	Carnauba wax	E903	INS No. 903	Candy, dried food, baked goods, marshmallows, sugar products, fruit juice, broth sauce
	Shellac	E904	INS No. 904	Apples, oranges, gum sugar base, roasted coffee, chocolate, wafer biscuits
	Beeswax	E901	INS No. 901	Fresh produce may be coated with glazing agents to improve their appearance and extend shelf life
	Candelilla wax	E902	INS No. 902	Used in other applications, including chewing gum, cosmetics, and even in some fruit coatings.
Artificial glazing agent	Hydrogenated poly-1-decene	E907	INS No. 907	Used in food to create a shiny, glossy surface on products like confectionery and dried fruits
	Microcrystalline wax	E905c	INS No. 905c	Used to give food items a shiny appearance and act as a protective coating

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Flavor enhancer

Flavoring agents are A number of food additives are used to improve flavour, taste and aroma to maintain food quality. Generally, natural and artificial both type of flavouring agents is used in various food products in food industry. The natural flavoring agents includesspices, herbs, roots, and essential oils, nut, fruit and spice blends, and derived from vegetables and wine have been used in the past as flavour additive. Flavoring agents are providing a distinct taste or smell. Flavouring additives are the naturally occurring ingredients that added into the food for a characteristic flavour. Monosodium glutamate (MSG) is the most common example of flavour and flavour enhancers, which is generally recognized as safe. MSG is composed of sodiumand glutamic acid (amino acid) found naturally in high protein foods such as meats and dairy products. It is also a flavour enhancer used in prepared meals, Chinese food, some sauces and soups. MSG has been caused a variety of side effects like headaches and body tingling, however some scientific studies shows that there is no link between MSG and these health issues (Nishioka et al., 2009; Alemu et al., 2022).

Contaminants

Codex Alimentarius defines "contaminant" each substance not intentionally added to the food, but found inside as a result of the production process, farming practices, treatment, packaging, transport or storage of food, or result of environmental contamination. Foreign substances such as insect fragments, animal hair, etc. do not included in this definition (Stefano &Avellone, 2014).They typically pose a health concern, resulting in strict regulations of their levels by nationalgovernments and internationally.They typically pose a health concern, resulting in strict regulations of their levels by national governments and internationally. Therefore, analysis of relevant chemical contaminants is an essential part of food safety testing regulatory limits.

Sometimes limited amounts of contaminants are allowed in foods because the contaminants cannot be completely eliminated without damaging the foods. Common contaminants are pesticides, heavy metals (lead, cadmium, mercury), nitrates (in green leafy vegetables), aflatoxins (in nuts and milk), growth-promoting hormones (in dairy products and meat), animal hairs and feces, and insect parts.The most notable of these are the products of mold growth called mycotoxins, which include the aflatoxins (Wuet al., 2021). Other mutagens may be present in foods as naturally occurring contaminants such as aflatoxin B_1, as unintentional contaminants such as industrial chemicals or pesticides, or as intentionally used additives such as nitrites.

They can be classified according to their chemical origin:

- Agrochemicals (pesticides, veterinary drug residues),
- Natural Toxins (mycotoxins),
- Toxins in industrial chemical processing (e.g., polycyclic aromatic hydrocarbons, phthalates, dioxins and polychlorinated biphenyls, acrylamide, perchlorate),
- Packaging-derived chemicals (bisphenolA, semicarbazide).

Agrochemical contaminants are chemicals, used in agriculture for the systematic elimination of specific species considered harmful for crops, such as bacteria, molds, fungi, insects, mice and other species (Metcalf, 2002; Stefano&Avellone, 2014).

U.S. Food and Drug Administration (FDA)-estimated safe levels are levels that have not caused illness or adverse effects in people. However, demonstrating a causal relationship between extremely low level exposures and adverse effects is difficult; long-term adverse effects, although unlikely, are still possible. Safe levels are often determined by consensus rather than by hard evidence. So-called endocrine disrupting chemicals in the environment (eg, insecticides, petrochemicals, industrial solvents, plasticizers) can affect endocrine systems and alter hormone levels, causing alterations in immune function, nervous system function, growth and development, and certain cancers.

Weighing the benefits of additives (e.g., reduced waste, increased variety of available foods, protection against food-borne illness) against the risks is often complex. For example, nitrite, which is used in cured meats, inhibits the growth of *Clostridium botulinum* and improves flavor. However, nitrite converts to nitrosamines, which are carcinogens in animals. On the other hand, the amount of nitrite added to cured meat is small compared with the amount from naturally occurring food nitrates converted to nitrite by the salivary glands. Dietary vitamin C can reduce nitrite formation in the gastrointestinal tract. Rarely, some additives (e.g., sulfites) cause food hypersensitivity (allergy) reactions. Most of these reactions are caused by ordinary foods ().

Contaminants can befound in foods by variety of sources, including use of agrochemicals (residues of pesticidesand veterinary drugs), contamination from environmental sources (water, air or soil pollution), contamination or formation during food processing, transferof packagingmaterials,by natural toxins or use of unapproved food additivesand adulterants.They generally pose a health concern, resulting in strict regulations of their levels by nationalgovernments and internationally. Therefore, analysis of specific contaminants is acrucial part of food safety programs to ensure consumer safety and compliance withregulatory limits. Modern analytical methods can evaluate and determinethe known contaminantsin complex food material at very low concentration levels (Abid et al., 2018).

The main objective of food safety and security is to safeguard consumer health while ensuring theorderly functioning of the market. The application of advanced technologies to foodcontaminants and residues has made it possible the analysea wide range of compoundswith high sensitivity, selectivity and specificity. As a result, modern analytical approaches allowed a more comprehensive assessment of food safety with the determination of trace levels in accordance with international regulationsand legislation (Stefano and Avellone, 2014; Codex Alimentarius Commission. 2021).

Regulation and assessment of food additives

The improper addition and use of natural and synthetic food additiveswill harm human health (Carocho et al., 2015). For example, boric acid was widely used as afood preservative from the 1870s to the 1920s, but wasbanned in World War I after studies on animal and human showed it to be toxic. A saffrole is naturally occurring insassafras and sweet basil, was firstly used as a food spice toflavor root beer until it found to be carcinogenic. Suchreports suggest that only additives with stable safety should beused in foods. Therefore, a series of standards related thetopic of food additives safety should be covered to introducenew safe additives and bans those questionable ones.In order to apply the same standard for food additives, theJoint FAO/WHO Expert Committee on Food Additives(JECFA) has been meeting annually since 1956 to updateand revise its related standards (Wissgott and Bortlik, 1996).According to laws, regulations and standards, illegal foodadditives or the abuse or misuse of food additives are usually assessedin two methods: component identification and content

determination.Themainobjectiveofthese finding are whether additivesare illegally used and the latter is to know if additives areexcessive. From this point of view, how to determine foodcomposition and additive content is an important issue toguide the laws and make sure foods are safe to the community. Therefore, it is of great importance to establishreliable and sensitive analytical methods for the inspection of food additives (Wu et al., 2021).

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