

# Food additives: Colorants

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Food additives are used to protect food, increase quality and extend shelf life in many stages, from production to consumption of food. Additives used in the food industry are added to the food during preparation, production, packaging and storage stages. Colorants added by food producers to color food or to adjust the color to desired level are among the commonly used food additives. Considering today's developing production technologies, foods fade or discolor at various stages of processing, storage, and sale due to physical and chemical conditions such as heat, light, pH and oxygen. Colorants are used to regain these color losses, to enhance weak colors, to give color to the food that is actually colorless, and to win back the favor of customers by hiding low quality. Colorants are used in the production of soft drinks, candies, bakery products, canned and vegetable products, dairy products, and meat and fish products.

**Keywords:** food additives; food technology; colorant; E code

## 1. Introduction

The need of using additives in the food industry arises from technological requirements. In addition, factors such as the increase in the world population, the decrease in raw material resources, and the tendency of people to raise the living standards are affecting technological developments. Different production techniques, diversification of products, increase in the tendency of seasonal foods to be consumed in every period of the year, extension of shelf life of the products and necessity of quality standardization have made the use of food additives compulsory in food sector [1]. The colorant additives used in the food industry are added in order to add color to the food during processing and storage [2-3]. Colorants differ from each other by various physical and chemical properties such as chemical structures, sources and usage purposes. In this paper; information on food additives, colorants and general properties of colorants, usage purposes and health issues is provided.

## 2. Food additives and their usage purposes

Food additives are added in various stages of food production with two main purposes; one is to make food safe by preventing bacteria growth, oxidation formation and other chemical changes and the other is to improve consumer's taste by enhancing the organoleptic properties such as color, appearance, flavor and smell of the food [4-5].

Some of the additives are produced from natural sources such as corn, beet and soybean, while others are artificial or synthetic. Nowadays, many consumers prefer to buy convenience food rather than preparing food at home. Convenience food containing additives and preservatives are not spoiled by bacteria and yeast, thus the quality and taste are preserved. There are more than 3000 antioxidants and preservatives having antimicrobial activity in the food industry. Salt and sugar are the most commonly used additives [3]. Spices and sulphites are also additives that have been used since ancient times in order to maintain the desired properties in the food production. With the development of the food industry in the 20th century, the use of new food additives has become inevitable for the production of many convenience foods [6].

Food additives are used in various processed foodstuffs such as non-perishable food, chips, ketchups, sauces, chocolates, puddings, colored candies, powdered drink mix, processed meat and dairy products, canned and fermented products, and instant soups [5]. The International Codex Alimentarius Commission (CAC), established by the joint efforts of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) defines **food additives** as “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, but added to the food with the intention of achieving a specific purpose, known for having safe dose levels and subjected to legal permission”. Food additives are substances added in the production, processing, preparation, packaging, wrapping, transport, preservation and storage stages [7,4,5-8].

It is known that salt was used for curing meat products in 3000 BC and human used to benefit from salt and wood smoke as food preservation method around 900 BC [7]. In general, additives have functions such as extending shelf life, increasing product quality and variety, making food production quick and easy, reducing costs, and achieving the production standards. Some additives are used to attribute new features to food while some are used to preserve their existing properties [4-5].

If a substance is added to food for a specific purpose, this additive is called the direct additive substance. For example, xanthan gum is a direct additive added to salad dressing, chocolate milk, bakery fillings, puddings. Usually

direct additives are written in the contents of the food label. Indirect food additives are substances that are added to food in trace amount during packaging, storage and other processes [5].

*Classification of food additives according to purpose of use [5-9].*

*1. Extending the shelf life by protecting quality (Preservatives)*

Antimicrobial substances: (nitrite, nitrate, benzoic acid, propionic acid, sorbic acid)

Antioxidant substances: (BHA, BHT, gallates)

*2. Improving food structure, preparation and cooking*

pH regulators

Anti-caking agent (silicate, magnesium oxide, magnesium carbonate)

Emulsifiers (lecithin, mono and diglycerides)

Stabilizers, thickeners, sweeteners

Fermentation agents

Moisture regulators

Maturing agents

Bleaches, fillers, foam conditioners, polishers

*3. Improving color and flavor*

Flavor enhancers (MSG)

Condiments (flavour substances)

Colorants (tartrazine, indigotine)

Protecting and improving nutritional value (nutritional elements)

Replacing missed nutrients during processing (B<sub>1</sub>, B<sub>2</sub>, niacin)

Adding nutritional elements that might be lacking in the diet (A, D vitamins)

## 2.1 Legal regulations on food additives

In order to make the relevant legal regulations it is crucial to classify the additives used in processed food production by analyzing their health conditions and decide whether they are favorable to use or not. For this reason, the legal use of food additives in food is regulated by the joint efforts of the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). The Codex Alimentarius Commission (CAC) was established in 1963 to carry out the joint work of these two institutions. The task of this commission is to regulate the standardization of food-related practices across the world in terms of health and technology. Documents prepared by this commission with this purpose are accepted as a reference for safe food production in all countries of the world. Codex Committee on Food Additives and Contaminants-CCFAC and Joint Expert Committee on Food Additives - JECFA are the two institutions working on food additives within this commission [7].

JECFA conducts studies on the safety of additives on human health and prepares lists of additives which are determined to be safe for use at certain doses. These committees investigate all scientific data of the food additives in their agendas, make evaluations, and identify ADI values by various means. The committees examine the food contaminants, naturally occurring toxic substances and veterinary drugs and determine the ADI and maximum residue limits (MRL) [3].

*ADI (Acceptable Daily Intake):* As a result of long-term and detailed toxicological studies carried out by experts working in the JECFA commission, the acceptable dose of additives for experimental animals is determined. This value for humans is calculated as follows; one mg per kilogram of body weight is determined first and this number is divided by 100, which is accepted as safety factor by the commission, in order to decide on Acceptable Daily Intake. The name of the additive and the maximum acceptable amounts in different food are determined in the lists prepared using this data. ADI is the maximum acceptable consumption amount of an additive per day. ADI values do not differ from country to country as they are stated as international standards. ADI values are not written on food labels. These values are stated in the relevant legislation and should be known by food producers [10].

*E code:* Each food additive that is permitted for use in the European Union countries is given an "E" code. The "E code" used to identify food additives, inform consumers and prevent any confusion, consists of the letter E of the European Union (EU) and three digit numbers. More than 8.000 food additives are available today. Only 350-400 of them have the "E" code. All chemicals that are defined as additives and used in food, whether natural or synthetic, are within this coding system. Food additives are sometimes written with their original names, sometimes only with "E" codes, sometimes with both. In addition to this code, there are also other internationally recognized numbering systems such as the INS (International Numbering System) or CAS (Chemical Abstract Service) [4, 3-11].

## 3. Color and colorants in foods

Usually the properties of food such as shapes, colors, tastes, smells and textures are improved to satisfy consumer expectations. Color is one of the most significant factors that directly affects consumers' food choice and eating desires

[12]. Color is a visual feature that arises from the spectral distribution of the light. The formation of light occurs from the interaction of matter and light, and humans see wavelengths between 380-770 nm. As for the other matters in nature, the colors of the food are also based on this basic principle [13]. Color that affects taste recognition and product acceptability might have influence on both actual and perceived nutritional value of food [8].

Color additives are any dye, pigment or substance that are capable of coloring (either alone or by reacting with other substances) when added to food, medicament, cosmetics, or applied to the human body [5]. Today, due to the development of the food industry, the need to colorize food products has increased for various reasons. The Codex Alimentarius Commission (CAC) defines colorants as substances added to color food or to correct the color of the food. In addition, the colorants are added to restore the natural color lost during processing and storage of the food, to enhance the existing color, to strengthen the weak color, to color the food which is actually colorless and to win consumers by hiding low quality [13, 2-3].

Colorants are usually added to processed food such as candies, snacks, margarine, cheese, soft drinks, jam/jelly, gelatin, pudding and pastry fillings [5]. It is known that in medieval ages nitrate was used to enhance the color of meat and to prevent botulism apart from salt and smoke that were used as preservatives. In addition, food colorants were used by Egyptians in 400 BC to regulate the color of wine and confectionery products [7]. Among the natural colorants added to food around the mid-1800s were vegetable-derived products such as saffron, carrot, mulberry and flower, various animal originated pigments, and minerals from copper and iron. The first synthetic dye obtained from organic coal tar was used in butter and cheese around the end of the 19th century [14].

### 3.1 Classification of colorants

Directives on colorants are examined in 3 groups. These are as follows:

1. Colorants whose ADI values are determined and allowed for use,
2. Colorants permitted to use only for special purposes (such as surface finishing) (CaCO<sub>3</sub>, aluminum, silver, gold),
3. Colors that are only allowed to use in some foods (Titanium dioxide, vegetable carbon, red beet)

The use of colorants outside of this classification is banned. Furthermore, despite the ban on the addition of colorants to products such as mineral waters, milk, flour and tomato paste, different implementations are applied in national legislation [15]. Colorants differ from each other by various properties such as chemical structures, sources, and purpose of use. As it is difficult to classify the colorants according to these properties, they are divided into two groups based on their sources as natural and synthetic [13].

#### 3.1.1 Natural colorants

The use of natural colorants is known to date back 2600 BC and written records have been found in China. It has been reported that food colorants were used in Europe during the Bronze age [16]. Natural food colorants, which continue to be used worldwide and known to have significant benefits when consumed, are demanded by people for their long or short-term effects as well as for their reliability, functionality, biological potential and health effects. Consumers perceive natural colorants as safer than to synthetic colorants which are thought to be harmful [12].

Many consumers associate good and natural looking food and drinks with high quality while they think the other way around when it comes to faded and artificial shining products. In addition, the production of colorants from known sources such as beetroot, grape, cabbage and paprika makes the consumer feel safe and makes it easier to familiarize and accept the product [17]. Natural colorants are less stable to heat, light or pH, and their production is inadequate to meet industrial demand. They quickly fade when exposed to light and shows low resistance to acidity and high temperature. For example, Annatto turns to pink from yellow at low pH and chlorophyll turns to brown from green [15]. This makes natural origin colorants more expensive. For example, natural red and yellow colorants may cost 100 times more than synthetic products with the same effect [8]. Natural coloring matters are synthesized by plant and animal organisms or microorganisms and they naturally exist in them. Pigments produced by modification of living organism materials such as caramel, vegetable carbon and Cu-chlorophylline (vide infra) are accepted as natural although they are not found in nature (except carbon). Nature identical colors are man-made pigments found in nature. Carotene, canthaxanthin and riboflavine are nature identical colors [2]. The most notable colorants obtained from animal sources are Natural Sepia (cuttle fish), Crimson (Kermes Louse) and Tyrian purple (Murex shellfish) [16].

##### 3.1.1.1 Organic natural colors

*Anatto*: Annatto is one of the oldest known natural carotenoids used as food colorant. Tropical annatto is a pigment derived from the pericarps of *Bixa orellana* L. tree seeds [18]. Having yellow-orange food colorant property, annatto is used in smoked fish, various beverages, bakery products, and dairy industry. [19]. It has also been reported that annatto is used especially in cheese, butter, margarine and snacks [20].

*Anthocyanins*: Anthocyanins are natural polyphenolic pigments group responsible for various colors of many fruits and vegetables ranging from red to blue. Typically, the most common sources of anthocyanins used in food industry are grape, elderberry and blackcurrant. Anthocyanins are also found in red beets, black carrots and so forth [17].

Anthocyanins are not only vegetative as plant roots, flowers, leaves and plant matrices are. Algae/microalgae, fungi/yeast and aquatic animals are also used as raw material to extract carotenoid pigments [12].

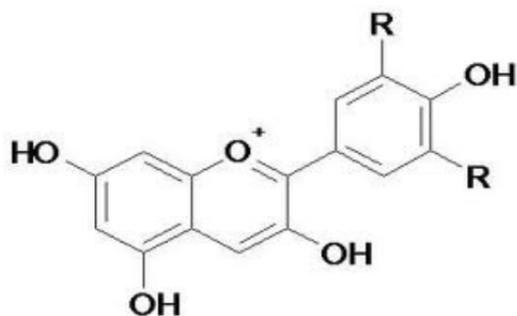


Fig. 1 Chemical structure of Anthocyanins [16].

*B-Apo-8'Carotenal and Carotenoic Acid Ethyl Ester:* Existing in the form of crystals or powder crystals and having a color of dark and red violet with a metallic lustre [13], they are used in the production of soft drinks, confectionary, coatings, soups, sweets and sauces [4].

*Vegetable Carbon (Vegetable Black):* Carbo vegetabilis or carbon black is the only natural color that provides shades of black or gray. It is used in candies, ice-creams and frozen sorbet [17].

*Caramel:* Caramels constitute more than 80% of all food colorants and are classified according to their production methods [19]. The distinctive taste, odor and the amber color that come out when heated is called caramel. Although not obtained from plants or animals, the caramel produced by heating the sugars is used in various food products. Sufficient pressure and temperature conditions must be provided during the caramel production process [21].

*Carotenes:* As they are added to foods with high fatty acid content, carotenoids are preferred in various food production. The main coloring substance of carotenes,  $\beta$ -carotene, is yellow and red [12].

*Chlorophyll:* Chlorophyll is common substance in nature which is a green pigment occurring as a result of vegetable and fruit plants photosynthesis [22]. Chlorophyll is used in bakery products, dairy products, candies, cereals, jams and jellies to give green color. Chlorophyll is also used as a complementary color when it is needed to dim off the yellowish cheese milk color [17].

*Carmine (Natural Red 4):* Dactylopius coccus (Cochineal) is a local insect in South America and Mexico. The pigment obtained from this insect and its egg is carminic acid [16]. Carmine is a compound that carminic acid creates with aluminum pigment. Since it is an expensive substance as a color additive it is not economical to use in food industry. Carmine is used to give pink color in dragee coatings and protein food as the use of FD&C pigments is unfavorable for protein food [23].

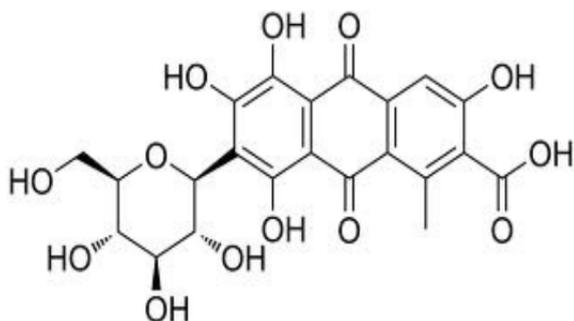


Fig. 2 Chemical structure of Carmine [16].

*Sepia officinalis L. (Female Cuttlefish):* This pigment, called Sepiixanthine, has a concentrated orange-red color. It is used as colorant and sweetener in pasta and sauce production. Usually, the ink of the cuttlefish is used in black pasta production. The most important colorant sources obtained from animals are Natural Sepia, Crimson (from Kermes Louse) and Tyrian purple [16].

*Curcumin (Turmeric):* Turmeric is a plant that is cultivated in many tropical countries, especially Curcuma longa and India. Curcumin is the main coloring pigment of turmeric which is used as a spice for thousands of years and is one of the main components in curry sauce [17]. Curcumin is mainly used in dairy products, beverages, cereals, mustard, food concentrates, pickles, sausages, confectionery, ice cream and bakery products. Mixed with annatto, it is also added to the seasonal sauces, mayonnaise sauces and butter [16-21].

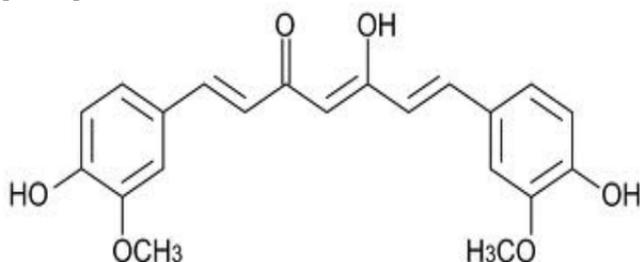


Fig. 3 Chemical structure of Curcumin [24].

*Lycopene and Lutein:* Lycopene, the main coloring substance of red tomato, is a carotenoid class colorant. This substance is dark red and viscose. Lutein, another colorant in the carotenoid class, is the main coloring substance of xanthophylls and gives yellow color [13].

*Beetroot Red:* The color pigments exist in the redbeet are red and yellow pigments. Redbeet is used in the

production of ice cream, dairy products, jams and jellies and give strawberry color in confectionery that are not exposed to high temperature [16].

*Paprika Extract:* The important pigments found in red pepper are a mixture of capsanthin and capsorubin. Both are carotenoids responsible for the red color of the dye [19].

*Riboflavin*: Riboflavin (vitamin B<sub>2</sub>), used as a yellow food colorant, is banned in most countries. It is used in many food products such as sorbet, various drinks, sweets and ice cream. Riboflavin is preferred in the production of cereal-based products, but its use is limited due to its mild odor and naturally bitter taste [2].

*Monascus purpureus*: Red pigments produced by the fungus named *Monascus purpureus* are used in traditional products in some countries due to their various properties. The use of these pigments has not yet been legally regulated in the European Union, the United States, Brazil, the Philippines and Taiwan. This pigment, which is soluble in water, has been used in confectionery and red rice wine production in Japan for many years. Additionally, this pigment has cholesterol-lowering properties [16].

### 3.1.1.2 Inorganic natural colorants

*Aluminium dust and silver* for silver gray color, *gold* for real gold color, *iron oxides* for yellow, red, brown or black colors, *titanium dioxide* for white color and *calcium carbonate* for opaque appearance are important inorganic natural colorants [13]. These colorants are used in the production of confectionery coating, liqueur decoration, chocolate, calcium carbonate, gum and bread [4].

### 3.1.2 Synthetic colorants

The substances which are not found in nature due to chemical structures and obtained by chemical synthesis are known as synthetic colorants [1]. The first synthetic organic color obtained is the purplish lilac color discovered by William Henry Perkin in 1856. It was obtained from the organic coal tar. Synthetic colorants have many advantages over natural colorants. Synthetic food colorants surpass natural colorants due to their high coloring ability, various color tone, homogeneous color distribution, brightness, stability, and ease of application [14]. With high water and oil dissolution properties, shelf life of the synthetic colorants are quite long. Chemical solubility matters when making a classification. Synthetic colorants are divided into three groups according to their solubility; [13].

- 1- Water soluble synthetic colors
- 2- Fat soluble synthetic colors
- 3- Oil soluble colors

#### 3.1.2.1 Water soluble synthetic colors

*Allura Red AC*: This synthetic colorant, generally known to be derived from insects, is actually produced from coal tar. Allura Red AC is used in the production of food like carbonated drinks, gums, snacks, sauces, soups, wine and especially apple wine. While European Union affirms its use; Denmark, Belgium, France, Switzerland, Austria, Norway and Sweden have banned it [3].

*Amaranth*: This substance gives reddish brown color and it is water soluble [13].

*Sunset Yellow*: Sunset yellow, which is orange red color, is usually used for food such as bread, drinks, cereals, sweet powders, ice cream and snacks [8].

*Brilliant Blue FCF and Brilliant Black BN*: Available in blue and black colors, it exists in powder and granular form. It is easily soluble in water while being less soluble in ethanol [13]. Brilliant black is used in the production of various cheese, wine, sauce and beverages [12].

*Tartrazine*: Tartrazine is used to obtain lemon yellow color and is added to food products such as bread, beverages, cereals, peanuts, confectionery, cream, ice cream and canned food [8-5].

*Erythrosine*: Being a xanthen-class colorant in the structure of benzoate, erythrosine exists the form of red powder or granules [13]. It is added to flavored milk and puddings, ice products, chewing gum and candies, jelly and drink powders [15].

*Quinoline yellow*: Quinoline yellow is a synthetic substance used to obtain a greenish yellow color. It is used in soft drinks, jams and canned foods, edible ice, sweets, candies, pickles, sauces and spices [4].

*Brown FK and Brown HT*: Brown FK is used in smoked and cured fish, meat and chips, while Brown HT is used in various biscuits, chocolates and cakes [12].

Other water soluble synthetic colorants are Green S, Indigotine, Patent Blue V, Litolurubin BK, Red 2G, Ponso 4R and Azorubin [13].

#### 3.1.2.2 Oil soluble synthetic colorants

Artificial colorants soluble in oil or organic solvents are insoluble in water as they do not contain groups capable of forming salt form as in water-soluble colorants. This group of colorants are not allowed to be used for food coloring because of their toxic properties. For example, the use of oil-soluble Penso SX for the coloring of butter and margarine was banned in 1976. Oil Red XO, Yellow AB used in the coloring of orange peels and Yellow OB are not allowed to use because of their toxic properties [13].

### 3.1.2.3 Lake colorants

Lake colorants are water-insoluble precipitation of aluminum hydrate substrate and are produced in the form of very fine powders. The dye content and particle size determine the color tone of the powder [25]. As they are not soluble in water, oil and other solvents, they are dispersed in food and produce color. They are used in cakes, biscuit fillings, confectionery, powder drinks, sweets, soups and spice mixtures [13].

### 3.2 Colorants used in food industry

The European Union has identified 43 colors and each of which is given an E number as a food additive. Of these, 17 are synthetic pigments and 26 are natural pigments [25]. Natural colors have always been part of the nutrition. Chlorophylls, carotenoids and anthocyanins are consumed with the food we eat every day [14]. Coloring of food with natural resources is thought to be healthier than coloring with synthetic dyes. For this reason, natural color formulations need to be developed for the use of food additives such as emulsifiers, carriers and antioxidants [26].

*Non-alcoholic beverages:* The non-alcoholic beverage industry has a significant share in the sales of food colorants. The coloring of soft drinks makes drinks more attractive and increases consumer perception of the overall fruit content and quality. All coloring categories such as synthetic, nature identical, natural and caramel colors (for coke) are used in non-alcoholic beverages [25]. In addition, Quinoline Yellow, Sunset Yellow FCF, Orange Yellow S and Brilliant Blue, banned in many European countries, are also used in non-alcoholic beverages [3]. Penso 4R, Brown HT, Brilliant Blue FCF, Green S, Quinoline Wax, Indigo Karmin are also used in soft drinks. While synthetic colorants are used in many fruit flavored soft drinks, cola and beer are colored with caramel [13]. Sunset Yellow is used in orange juice, Tartarizine in lemon juice, Penso 4R in cherry juice, Carmoisin and Sunset Yellow in strawberry juice, Carmoisin and Penso 4R in raspberry juice [15]. Allura red and Brilliant Black are used in wine production [12-3].

*Sugar products:* Usually Amarant, Penso 4R, Allure Red AC, Sunset Yellow FCF, Tartarizine and Karmoicine as well as Brown HT, Black PN, Brilliant Blue, Patent Blue, Erythrocin and Indigo Karmin are used in confectionery products. The amount of colorant added depends on the preferred color tone. Excessive coloring causes non-attractive dull color. The use of Lake colorants is recommended to use in chewing gums, bonbons and dragées in order to make synthetic colors leave color on mouth [13]. In addition, inorganic natural colorants such as Gold, Silver, Aluminum powder and Iron oxides are used in confectionery surface coating, chocolate and liquor decoration [4].

*Bakery products:* Colorants are widely used in dough products, biscuits, cake creams and coatings. Caramel and carbon black are used in combination with synthetic colorants. Caramel is crucial in the coloring of rye bread. Allure Red AC, Sunset Yellow FCF, Brown HT, Tartarizine, Penso 4R are the most preferred colorants in baked products [13]. Tartarizine, Penso 4R, Sunset Yellow FCF are also used in chocolate cake, breakfast snacks, plain cakes and wafers [15].

*Canned food and vegetables:* The colorants to be added to canned food must be resistant to sterilization or high cooking temperature and acidic environment conditions. Amarant, Penso 4R, Allure Red AC, Sunset Yellow FCF, Red 2G and Indigo Karmin are the most commonly used synthetic colorants in canned fruit. Anthocyanins,  $\beta$ -carotene, Carminic acid and Chlorophyll are natural colorants used in canned fruits and vegetables [13].

*Dairy products:* The addition of liquid dyes to ice cream is done after pasteurisation. Some cheeses and butter are colored with  $\beta$ -carotene and anatto [15]. In addition Sunset Yellow FCF, Penso 4R, Indigo Carmine, Erythrocin, Tartarine, Amarant and Allure Red are also frequently used in dairy products. Almost all kinds of ice cream are added with synthetic colorants. Sunset Yellow FCF and Tartarissin color mixtures are widely used in ice cream cones [13]. Sunset Yellow FCF and Carmosine are used in yogurt production [3].

*Meat and fish products:* Carmosine, Erythrocin, Tartaricin, Allure Red AC and Red 2G are widely used colorants in meat and fish products. Water-soluble colorants suitable for pickling conditions are required for fish products produced by curing or smoking. For these practices, it is stated that Brown FK is particularly favorable, and in some cases mixtures of Carmosin, Tartarizin and Sunset Yellow FCF are also used [13].

### 3.3 Legal regulations on colorants

Today, in all countries of the world, food additives and especially colorant-related regulations are in focus. Moreover, despite global cooperation and harmonization efforts, these regulations vary from country to country [27]. The European Food Safety Authority (EFSA) and the Food and Drug Administration (FDA) are the most important regulatory bodies authorized to protect and improve human health, as well as to ensure the quality and safety of food products [12].

The FDA has primary legal liability for determining and regulating the safe use of food additives. Food manufacturers must first get approval from the FDA to use a new colorant in food production [5]. In developed countries, the use of colorants in the food industry depends on a number of toxicity tests (such as detection of the acute, subchronic and chronic toxicity, carcinogenicity, mutagenicity, teratogenicity, reproductive toxicity, accumulation in the body, bioenergy effects and immune effects) [28]. Currently, 16 natural color pigments and synthetic origin 9 color pigments including lutein are allowed to use in European countries but vegetable carbon, aluminum, silver and gold, chlorophylls and chlorophyllins and calcium carbonate are not allowed in the USA [27]. The natural colorants

permitted to use are betaines-betaines, quinones-cocineal, flavonoids-anthocyanins, isoprenoids-carotene, annatto (bixin, norbixin), red pepper extract, lutein, canthaxanthin, porphyrins-chlorophylls chlorophyllin of these compounds and copper complexes, caramels and curcumin [21].

To distinguish food colorants from other colorants, an FD&C number is issued by the FDA to the colorants permitted under the Food, Drug and Cosmetic Act. Similarly, the European Union has also given the E code number to the colorants allowed to use. For this reason, in some cases there might be 3 different code numbers for the same colorant in the literature. For example, the CI number is 15985, the FD&C number is Yellow 6, and the E code is E110 for Sunset Yellow [13].

### 3.4 Colorants in health aspects

Different views emerge when the food additives are assessed in terms of health risk. Most people think that food safety regulations are inadequate for consumer protection [29]. Consumers see naturalness as an important property and natural foods are considered to be safer and even healthier than artificial food [30].

It is known that children are always interested in foods and drinks with vibrant colors. For this reason, adding attractive colors to the food is thought to increase the taste and appetizing properties of food and drinks for consumers [31]. However, it has long been argued that synthetic food colorants and other food additives have an adverse effect on children's behavior. The effects of these substances can manifest as behavioral disorders, hyperactivity and attention deficits that show significant individual differences on children [32, 33-28]. In a study conducted, it is reported that Brilliant Blue, Tartrazine FD&C Yellow No 5 cause hyperactivity disorder [3]. In addition, six of the most common synthetic food colorants that are reported to have negative effects on attention deficit and hyperactivity are tartrazine (E102), quinolone yellow (E104), sunset yellow FCF (E110), carmoisine/azorubine (E122), Ponceau 4R (E129) and Allura Red AC (E129). These products are especially exist in sugary products and beverages [12]. Especially Allura Red AC can cause cancer, chromosomal aberration, developmental toxicity, DNA damage, genotoxicity, hyperactive behavior in children, neurotoxicity, psychotoxicity, reproductive toxicity [34].

In recent years, an increase in the incidence of allergies and asthma has been observed in humans, and this increase has been associated with food additives, especially with colorants [28]. Synthetic food additives have been shown to increase the urticaria and asthma in some individuals [35]. It has been reported Allura Red, one of the colorants, increases asthma and urticaria while Tartarin causes asthma and migraine [3].

In addition to the negative effects of synthetic colorants on health, colorants that affect health in a positive way are also available. The positive relationship between health and carotenoids has been found by the discovery of  $\beta$ -carotene, an important pigment in skin protection and cell growth [19]. Lycopene, a natural pigment found in tomatoes, is effective in reducing all types of cancer, especially the risk of breast, prostate and cervical cancer [25-24].

It has been determined that curcumin is a powerful antioxidant and protects against oxidative damage in cellular components and is effective in the treatment of wounds and burns. Curcumin has been found to prevent cancer formation and progression, increase the activity of certain enzymes responsible for digestion, promote detoxification of liver which acts as an antibacterial agent and even have anti-HIV properties [25-36]. Antioxidant activity of carotenoids, having coloring property, pre substance of vitamin A, protects against oxidative damage and is evaluated positively for health [25].

## 4. Conclusion

Today, factors such as increase in food production variety, diversification of technological developments and changes in consumer nutrition habits have increased the number of processed foods. In many countries, the use of food additives has been compulsory to ensure the quality characteristics of processed foods and to extend shelf life. In particular, the coloring additives used in color formation, which plays an important role in consumer preferences, are added to give color to the food and to win the consumers. Colorants are used in many food industries, such as the production of soft drinks, confectionery, bakery products, canned and vegetable products, dairy products and meat and fish products. When evaluated in terms of health aspects; the use of additives must be performed within the limits and to fulfill a certain function within the legal framework.

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