Süleyman Demirel Üniversitesi
Sağlık Bilimleri Dergisi
Cilt 13, Sayı 1, 146 - 152, 2022

Suleyman Demirel University
Journal of Health Sciences
Volume 13, Issue 1, 146 - 152, 2022

Food Color Additives and Health Interaction

Gıda Renklendiricileri ve Sağlık Etkileşimi

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ABSTRACT

Colorants, which have an important place in food additives, are defined by the International Food Codex Commission as "a substance that regulates the color of food or is added to give color". The Joint FAO/WHO Expert Committee on Food Additives (JECFA) affiliated with the Codex Alimentarius Commission (CAC) formed by the World Health Organization (WHO) and the Food Agriculture Organization (FAO) as part of the United Nations (UN) organization, is an authority that makes suggestions and recommendations on all matters concerning the additives. Different opinions have emerged in studies evaluating food additives in terms of health risks involved. In various studies investigating colorants in foods, it has been reported that the permitted colorants are used in high amounts and also that non-permitted colorants are encountered. In various epidemiological studies, it is stated that colorants cause diseases such as asthma, hypersensitivity, skin rashes, premature childbirth, migraine, cancer, thyroid, tumor, and chromosome damage in humans.

Keywords: Food color additives, health, interaction

Alınış / Received: 15.10.2021 Kabul / Accepted: 17.02.2022 Online Yayınlanma / Published Online: 15.04.2022

DOI: 10.22312/sdusbed.1010114
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ÖZET

Gıda katkı maddeleri içinde önemli bir yere sahip olan renklendiriciler, Uluslararası Gıda Kodeksi Komisyonu tarafından "gıdanın rengini düzenleyen veya renk vermek için eklenen madde" olarak tanımlanmaktadır. Birleşmiş Milletler (BM) organizasyonunun bir parçası olarak Dünya Sağlık Örgütü (WHO) ve Gıda Tarım Örgütü (FAO) tarafından oluşturulan Codex Alimentarius Komisyonu (CAC) ile bağlantılı FAO/WHO Gıda Katkı Maddeleri Ortak Uzman Komitesi (JECFA), katkı maddeleri ile ilgili tüm konularda öneri ve tavsiyelerde bulunan bir kuruluştur. Gıda katkı maddelerinin içerdiği sağlık riskleri açısından değerlendirildiği çalışmalarda farklı görüşler ortaya çıkmıştır. Gıdalarda renklendiricilerin araştırıldığı çeşitli çalışmalarda izin verilen renklendiricilerin yüksek miktarlarda kullanıldığı ve ayrıca izin verilmeyen renklendiricilere rastlandığı bildirilmiştir. Çeşitli epidemiyolojik çalışmalarda renklendiricilerin insanlarda astım, aşırı duyarlılık, deri döküntüleri, erken doğum, migren, kanser, tiroid, tümör gibi hastalıklara ve kromozom hasarına neden olduğu belirtilmektedir.

Anahtar Kelimeler: Gıda renklendiricileri, sağlık, etkileşim

1. Introduction

In recent years, with the rapid increase of the world population, awareness of people, changing consumer tastes, diversification of food products, increasing tendency to consume seasonal foods year-round, increased shelf life of foods, the necessity of standardization in quality, and the need for the rational use of decreasing food resources have increased the necessity to use food additives. Food color additives, which are an important group of food additives, play an important role in increasing the attractiveness of foods.

In foods, color is a visual feature consisting of the spectral distribution of light. The formation of the color occurs as a result of the interaction of the matter and light, and the wavelength of the colors is indicated as nanometer (nm). The colors of natural foods are caused by substances, defined as pigments, with a wide variety of chemical forms. For example, many foods of natural origin, such as vegetables and fruits, have a variety of colors, and their attractiveness is related to their color. Considering the recent food production technologies involved in various stages such as processing, storage, and sale, foods' colors may fade out partly or completely due to physical and chemical conditions, such as oxygen, pH, light, and heat. Food color additives are used to protect the quality of the food by increasing the naturally occurring color or by replacing the lost color, to create a standard color in the product technologically, to create different colors, or to obtain attractive and acceptable products. In food color additives, which have a wide range of use in food industry, the unique colors of raw foods can be used, and desired colors can also be created with some processes.

While recent innovations in food coloring eliminated some problems encountered previously, it also brought some new problems with it. The careful use of color additives is gaining importance day by day due to changes in consumer demands, legal regulations, and the presence of side effects on health.

Food Color Additives

Definition

In the Turkish Food Codex Regulation, the food additive is defined as follows: under normal conditions, it is not consumed alone or used as a food raw material; they are with or without nutritive value alone; and, they are substances whose residues or derivatives can be found in the finished product based on the technology chosen. In addition, they are substances that are allowed to be used in order to preserve and improve the taste, smell, appearance, structure, and other qualities of the food during the production, classification, processing, preparation, packaging, transportation, and storage [1]. Colorants, which have an important place in food additives, are defined by the International Food Codex Commission as "a substance that regulates the color of food or is added to give color" [2]

History

In prehistoric times, natural colorants obtained from only plants and animals were used. The use of colorants in foods first began with the addition of natural pigment extracts to sugars produced in Egypt in 1500 BC [3]. With the discovery of the first synthetic food color additive by Sir William Perkin in 1856, the colorant industry started to develop and synthetic food color additives were added to foods [4]. The use of natural and synthetic food color additives for coloring with many different purposes and methods has continued from ancient history to the present day [5].

Numbering

According to the Turkish Food Codex Regulation, it is obligatory to write the name or the E code together with the function of the additive added to the food in the table of contents on the food label [6]. The E number identifies food additives. The E code consists of the letter E and three/four numbers used in the European Union (EU) to avoid any confusion. All food additives used in coloring, whether natural or synthetic, are in this coding system. All food color additives whose E numbers are specified in the Turkish Food Codex Regulation are substances included in the Codex Alimentarius Commission (CAC) lists. According to their basic functions, food color additives are numbered between E100 and E199 in E code classification system [7].

Grouping

Natural Food Color Additives: Since they are synthesized from vegetable and animal organisms or microorganisms, they exist naturally in their structures. Some of them are present in the natural structure of minerals [8]. Main pigments are examined under three groups as anthocyanins, carotenoids, and chlorophylls. In addition, betalains, anthraquinones, naphthoquinones, iridoids, phycocyanins, animal pigments, caramelization, and Maillard reactions are widely known food colorants. Natural food colorants are more expensive due to production costs. When exposed to light, they easily fade, and they show low resistance to high temperature and acidity [9,10].

Semi-Synthetic Food Color Additives: They are produced by various processes that are applied to substances obtained from natural sources [9].

Synthetic Food Color Additives: These are also called "coal tar dyes" because the starting material in the synthesis of almost all of them is coal tar. Several factors such as pH, acid, salt, light, heat, and preservatives affect the stability of synthetic dyes [11,12].

Toxicological Evaluation

Before food coloring agents are approved, the potential hazards associated with each additive are scientifically evaluated [13]. Even after the use of colorants as additives is approved, studies on these additives are carried out and continuous risk assessment is made based on new findings [14,15].

The procedures applied in the research of the effects of food additives on health:

1. Experimental animals are given a lethal dose ([LD50]: the dose that causes 50% of the experimental animals to die).
a. Dose is reduced slowly and the dose-response relationship is investigated. In every dose, the absorption, metabolism, and excretion of the additive are examined.
b. The cells, tissues, and organs of the experimental animals are examined and their carcinogenic, mutagenic, teratogenic, and allergic effects are investigated.
2. If a dose in which the additive has no effect is not found, it is not allowed as a food additive.
3. The no-observed-adverse-effect level (NOAEL) is determined: With the NOAEL dose found, daily dose amounts without carcinogenic, mutagenic, teratogenic, and allergic effects in various organs of the body are determined in milligrams per kilogram of the animal in a period of 85% of the life span of the experimental animals. Since the experiment cannot be performed in people for ethical reasons, safety factor is used. In other words, 1/100 of the dose that has no effect on the experimental animal is accepted for human. Acceptable Daily Intake (ADI) is determined as "NOAEL/100". The ADI value is determined in milligrams per kilogram of human body weight. The daily maximum intake is determined as "ADI x Body Weight".
4. The second step in determining the maximum amount of additive to be added to the food is to determine the Good Manufacturing Practice (GMP) as part of ADI. If the GMP amount and the ADI value are exceeded, the use of the additive is not allowed [14-16].

Legal Evaluation

The Joint FAO/WHO Expert Committee on Food Additives (JECFA) affiliated with the Codex Alimentarius Commission (CAC) formed by the World Health Organization (WHO) and the Food Agriculture Organization (FAO) as part of the United Nations (UN) organization, is an authority that makes suggestions and recommendations on all matters concerning the additives [13]. The JECFA and the European Food Safety Authority (EFSA) carry out detailed toxicological studies for substances intended to be used as food additives and prepare lists for the ADI levels and the use of substances to be approved for use in foods. The legislation regulating the use of food additives in Turkey is the “Turkish Food Codex Regulation”. In this regulation, the usage limits of food additives are determined based on the ADI values determined by international organizations [14,16]. In the Turkish Food Codex Notification on food color additives prepared in accordance with the Turkish Food Codex Regulation, the provisions regarding the use and labeling of colorings in additives are specified [4].

Food Color Additives and Health

Different opinions have emerged in studies evaluating food additives in terms of health risks involved [17]. For example, there are also colorants that affect health positively. The relationship between health and carotenoid intake emerged with the discovery of carotene, which is known as the precursor of vitamin A, an important molecule in skin protection and cell development [18]. Curcumin has antioxidant properties and is known to have therapeutic properties in cancer prevention, wounds, and burns [19]. If unauthorized additives are used, i.e., illegally, and if they are used above the permitted limits or in foods that are not allowed, they may be harmful to human health [20]. In various studies investigating colorants in foods, it has been reported that the permitted colorants are used in high amounts and also that non-permitted colorants are encountered [21,22]. In various epidemiological studies, it is stated that colorants cause diseases such as asthma, hypersensitivity, skin rashes, premature childbirth, migraine, cancer, thyroid, tumor, and chromosome damage in humans [15,23]

Table 1. Some Studies About Food Color Additives and Health				
Source	Country	Characteristics	Outcome measure	Health Effects
Pelsser et all. 2009 [24]	Holland	A randomized controlled trial 27 children with attention deficit hyperactivity disorder (ADHD) Average age 6.2 years Control group (n=15) - few foods diet Intervention group (n=12) - elimination diet	ADHD	ADHD symptoms decreased in 73% of the children according to the parent's assessment and in 70% according to the teacher's assessment, while these rates were 12% and 0% in the control group, respectively.
Bateman et all. 2004 [25]	UK	A double blind, placebo-controlled study 100 children with ADHD Average age 4-8 years Control group (n=50) - healthy diet Intervention group (n=50) - elimination diet	ADHD	In terms of ADHD symptoms, 78% of the intervention group had a positive response to diet.
McCann et all. 2007 [26]	UK	A randomized, double-blinded, placebo-controlled trial 153 (3-year-old) and 144 (8/9-year-old) children The challenge drink contained sodium benzoate and one of two artificial food colorings mixes (A or B) or a placebo mix.	A global hyperactivity aggregate (GHA)	Mixture A was significantly inversely associated with hyperactivity in all 3-year-olds compared to placebo. This effect was not seen in Mixture B.
Yadav et all. 2016 [27]	Hong Kong	A randomized, double-blind, placebo-controlled trial 130 children (8/9-year-old) AFCs (capsule A), sodium benzoate (capsule B), and placebo (lactose)	ADHD	Capsule A containing AFCs and Capsule B containing sodium benzoate had no significant adverse effect compared with placebo in both behavior scores.
Yuet-Wan et all. 2010 [28]	Hong Kong	A field survey 64 children (8/9-year-old) The food frequency questionnaire A total of 87 foodstuffs were analyzed for 11 synthetic colors HPLC with photodiode array detection	Color additives in snack foods	Dietary exposure to synthetic colors was considerably lower than the acceptable daily intake. Data from HPLC analyses showed that several synthetic colors, which were labelled as present in the food, were not detected and vice versa.

2. Conclusion

In addition to the diverse and economically accessible food supplies that will provide people with adequate and balanced nutrition, priority is also given to the appearance of foods. "Color" comes first among the features that draw our attention in foods and enables us to have an idea about the taste or quality of foods. Criticisms regarding food quality is firstly about its color, which reveals the need for coloring foods. Many additives with coloring properties have different chemical, physicochemical and physical properties due to differences in their chemical structures, so these properties determine which types of products they will be used in, in what form, and for what purpose. Therefore, it is necessary to have sufficient chemical and physical knowledge about the structures of the colorants to use them as food color additives.

Today, the use of food color additives is an inevitable requirement. These color additives, which are very diverse and added in foods for different purposes, are chemical compounds, and if they are consumed in larger amounts than recommended, they may show harmful effects on human health. In determining the maximum amount of colorants to be added to foods, good manufacturing practice applications should be taken into consideration, and at the same time, studies should be conducted to determine how many kinds of food color additives will be added to the food. In addition, exceeding the legal limits of food colorants used in production should be prevented by raising awareness in food manufacturers. It is also important to provide consumers with access to accurate information on food colorings, they should gain the habit of reading labels, and they should be provided with the relevant supervision and control mechanisms by legal authorities at all times to protect their health from the hazards resulting from food colorings.

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