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HAZARDOUS EFFECTS OF SYNTHETIC FOOD COLOR: A REVIEW

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ABSTRACT

The color of food is an important aspect, and it's probably what people notice with their eyes first. From unprocessed products to finished goods, almost all foods have a corresponding color. Artificial colors are another name for synthetic food colors. These are produced through chemical reactions, and the food and pharmaceutical sectors frequently use them. Food color plays a pivotal influence in visually increasing appetite. By utilizing color, we can bring out a dish's inherent color and add beautiful hues to other foods. Colors are added because meals that are off-color are typically thought to be of lower quality. Moreover, these colors have zero nutrient benefits and no preservation properties. They only make food appealing to satisfy new customer demands, as the consumers are expected to select products primarily based on how they look. According to the study, confections and beverages have a significant tendency to use artificial food colors, and certain confectioneries even contain a textile dye. Therefore, it is strongly advised that rules and initiatives to educate consumers and food makers about food colors be put into place.

Keywords: Synthetic colors, food, artificial colors, food color, chemical.

Introduction

The legacy of food colorants stretches back to the ancient Roman Civilization when people colored their meals with saffron, different flowers, pomegranates, beetroots, and other natural ingredients. They even employed specific ores and minerals, like copper or silver, to beautify the cuisine with vibrant, brilliant hues. Meal coloring was primarily used to provide a pop of color to bland food or to cover up any cooking flaws. Humans started using synthetic colors for this purpose in the mid-19th century in place of natural colors. Since then, despite their legal ban, widespread usage of synthetic food colors has grown quite frequent due to the rise of packaged and fast food cultures (*Food Coloring History The Color In Your Food by Yummytummy | <https://ifood.tv/>, n.d.*).

The tendency to replace synthetic food colorants with natural ones as concerns about the quality of some regularly used legal food colorants are growing. In addition, it has been demonstrated that several colors suspected of having carcinogenic qualities are illegally added to meals. To ensure that the food is free of dangerous colors, effective monitoring programs built on trustworthy detection techniques are necessary (Oplatowska-Stachowiak & Elliott, 2017).

Compared to natural dyes, synthetic food colors have a number of economically significant advantages, such as reduced costs, greater color stability, and resilience to heat, air, and pH changes (Alves *et al.*, 2008). It does not deteriorate while being processed into food and can be utilized right away (Schuster & Gratzfeld-hüsgen, 2009).

Various divisions in colors: There are three different types of colors which could be used in food:

- Synthetic Colors
- Natural Colors
- Inorganic Pigment

Synthetic Colors: A lot of azo and triarylmethane dyes are used as artificial colors in foodstuffs. The majority of them are acidic with carboxylic acid or hydroxy groups that, at basic pH ranges, produce highly reactive colored ions.

For example:

- **Amaranth** in the US was among the most popular red colors and was delisted in 1970.
- **Indigo carmine** was delisted in 1980

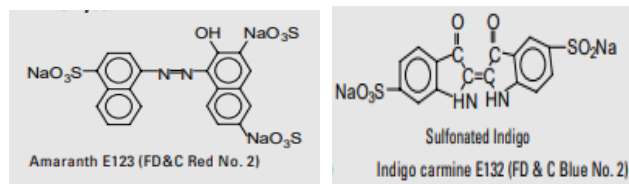


Fig. 1 : Chemical structure of (a) Amaranth & (b) Indigo Carmine

Natural Colors: Various consumable natural resources, such as flowers, veggies, and other edible natural sources, are used to produce natural food colors. They come in many different forms, including fluids, powder, and paste form. Both industrial food production and cooking at home incorporate food coloring (*NATCOL | Introduction to Natural Food Colors, n.d.*).

For example:

- **Betanin-** Beetroot's color is soluble in water and only somewhat stable in the presence of heat, light, and oxygen. It works particularly well with frozen, dry, and perishable goods like yoghurt and ice cream.
- **Anthocyanin-** Various flowers and vegetables have appealing red, purple, and blue colors because of anthocyanin, which are water-soluble pigments. Used in beverages, jams, and sweets made with sugar.

Inorganic Pigment: The inorganic pigments are typically incorporated when it comes to coloring compounds. Other pigments can't compare to inorganic pigments. Because they are formed from sulfides and oxides and include necessary mineral components, inorganic pigments are in high demand. All of these contribute to maintaining optimum color stability at all times. Utilizing inorganic pigments has a number of benefits beyond color composition (*What Is an Inorganic Pigment? Advantages of Inorganic Pigments - Koel, n.d.*):

- More durable
- Compared to other pigments, a lot less expensive
- ability to endure environmental factors

Natural color Versus Synthetic color

- If the color comes from plants, microbes, or minerals, it is considered natural. Contrarily, synthetic colors are produced in a laboratory by biologists.
- Consumers prefer the use of natural colors rather than synthetic ones since it is generally acknowledged that they are healthier for your health.

Artificial food colors such as Tartrazine (19140), Sunset Yellow (15985), and Ponceau 4R (16255), have been related to rise in children's hyperactivity. Tartrazine is one of the synthetic food dyes that might trigger an intolerant reaction in those who are vulnerable. The evaluations of natural colors, however, are dependent on a variety of assumptions and have only been evaluated to a limited extent (Oplatowska-Stachowiak & Elliott, 2017).

Health benefits of Natural Food colorants

- The colors are extracted from vegetables, fruits and elements
- Natural food colorants are good for health.
- Doesn't contain harmful elements that effects humans and animals

Purpose of Food coloring

- Enhancing the appearance of food
- For artistic or decorative uses, like cake frosting
- Giving food its own individuality
- Enhances flavor
- Used to alter the color of food or drink.

Permissible limit of Synthetic Food colors

The range of synthetic colors is maximal. Typically, this represents 100 ppm of the finished product intended for ingestion. However, the maximum limit of approved synthetic food colors in various foods and beverages, as noted in regulations, could be up to but not exceed 200 ppm of the finished food or beverage intended for human consumption (*Function of Colours in Food and Colours Permitted by FSSAI in Foods - Food Safety Helpline, n.d.*).

This review paper's objective is to provide the most recent information on the numerous issues raised by the usage of food coloring additives. The most important food health and safety concerns in the area of food colors are the lack of global regulation on legal food colors, the replacement of synthetic colors with natural ones, and the presence of harmful illegal colorants - both well-known and new, developing ones - in food.

Literature Review

The illegal use of artificial colors in various traditional juices and beverages was demonstrated in (Gholami *et al.*, 2021), which is concerning for the general public's health, particularly for young children. Most countries currently only authorize a very small number of synthetic color additives due to their potentially dangerous consequences. Different artificial food colors are legal in different countries. Despite the fact that only nine synthetic food colors are approved in Sri Lanka as edible, there are sixteen allowed in Europe, eighteen in Pakistan, seven in the USA, thirteen in Iran, and nine each in Australia and Sri Lanka (Saleem *et al.*, 2013; Suh & Choi, 2012).

This study demonstrates the dangers of Tartrazine on public health and establishes solid scientific proof of the relation between Tartrazine and mood disorders such as anxiousness, and antisocial behavior in weanling rats (El-Nabarawy *et al.*, n.d.).

The Brazilian Agency set limitations on the number of various food colors that could be present in various foods in Brazil. The agency only permits the use of nine food colors in food products. However, Brazilian law does not require the declaration of the additional colors' real concentrations, even though doing so is required on product labels. Table 2 shows the maximum concentration of a few synthetic food colors that can be used in food products (Alves *et al.*, 2008)

Table 2 : Brazilian laws' on the concentration of colors in several food stuffs

Colors	Juice powder (mg/100g)	Jelly powder (mg/100g)	Soft drinks (mg/100ml)
Red 40	10	15	10
Tartrazine	10	15	10
Sunset yellow	10	10	10
Amaranth	5	10	5
Brilliant Blue	10	15	10

The results of the study (Wu *et al.*, 2021) suggest that Tartrazine may have harmful effects on fish even in small quantities, which may pose a concern to human health. The outflow of these colors into waterways would have a significant impact on aquaculture, thus it is important to properly enforce environmental pollution prevention measures.

Classification: The following Table - 1 lists the classification of artificial food colors. The first synthesized color is Mauveine which was manufactured in 1856. Given the significance of synthetic food colors, various techniques for extracting and identifying them have been created. Either adsorption on wool is used to extract from the food sample. The various colors used in food manufacturing can be identified using a variety of techniques. Chromatographic techniques are typically used. Several artificial food colors

were used in desserts to test the method's applicability. The primary role is played by paper chromatography. The results

using paper chromatography were judged to be trustworthy (Bachalla, 2016).

Table 1 : As per PFA, artificial food colors are classified.

S. No.	Color	Common Name	Color shade	Color Index	Empirical Formula
1.	Red	Carmoisine	Red	14720	$C_{20}H_{12}N_2O_7S_2Na_2$
		Erythrosine	Bright Pink/ Red	45430	$C_{20}H_8O_5I_4Na_2$
		Ponceau 4R	Strawberry Red	16255	$C_{20}H_{11}N_2O_{10}S_3Na_3$
2.	Yellow	Tartrazine	Lemon Yellow	19140	$C_{16}H_9N_4O_9S_2Na_3$
		Sunset Yellow	Orange	15985	$C_{16}H_{10}N_2O_7S_2Na_2$
3.	Blue	Indigo carmine	Royal Blue	73015	$C_{16}H_8N_2O_8S_2Na_2$
		Brilliant Blue FCF	Turquoise Blue	42090	$C_{37}H_{34}N_2O_9S_3Na_2$
4.	Green	Fast Green FCF	Sea Green	42053	$C_{37}H_{34}N_2O_{10}S_3Na_2$

Effects on human

Food poisoning could result from adulterations. Food illness, fatalities, and even adulterations of synthetic food colors are more likely to occur, especially in youngsters. According to a number of studies (Dilrukshi *et al.*, 2019; Nath *et al.*, 2015), Market-available items like bakery goods, confections, and beverages commonly incorporate artificial food coloring. Market-available foods and beverages may have both an excessive amount of legal artificial colors as well as certain prohibited synthetic colors. Synthetic food colors have been linked to serious health issues like allergies, low hemoglobin levels, genetic abnormalities, irritability, restlessness, effects on the organs, and, hyperactivity in children (KS & KJ, 1994; Tuormaa, n.d.).

Effects on Animals

Pet food frequently comes in a spectrum of hues, and this is no accident. It's pleasant to see the golden chicken, and the scarlet of rare steak, when you unzip a package since these colors represent the original components' colors, which may lose during the production process. These colors are added after the event. The colors are actually included to attract pet parents because dogs and cats can't see the same range of hues that humans can. The use of these harmful food colors was outlawed by the Food and Drugs Act of 1906. Colors are frequently added to hide rotting or discoloration of food. Even though some food dyes, especially when used in large quantities, might well have cancer-causing effects, are not currently among the colors that the FDA has approved. FDA-approved colors should be harmless in foods for both people and pets if they are used as directed (Spence *et al.*, 2010). Animals exposed to semi-toxic concentrations of Sunset blue experience abnormalities in their body's overall lipid storage. This would have an impact on their metabolism and could result in dangerous liver damage including necrosis (Kumudu *et al.*, 2015).

Application of Food color

There are various sectors in which food colors are frequently being used.

Bakery: To meet the needs of clients, the bakery goods, such as cakes, cupcakes, tarts, etc., include a variety of colors. These colors are produced using only the finest raw materials. The purity and quality requirements for these hues are very strict (John *et al.*, 2022; Medeiros *et al.*, 2012).

Pharmaceutical: The human provides a broad range of pharmaceutical hues to fulfill client needs. These food colors

are frequently used as agents in the pharmaceutical and food industries because of their remarkable flexibility and diversity. Pharmaceutical colors are available in tablets, mouthwash, gels, and in a number of other forms (John *et al.*, 2022; Pandey *et al.*, 2012).

Seafood: For the purpose of using seafood applications, people supply a color. These colors can be found in both fish coating and smoked fish. Food agents are where it is frequently utilized. These hues truly reflect the freshness and are safe. Additionally, it is tested in a number of rounds by experts (Abuladze *et al.*, 2008; John *et al.*, 2022).

Cosmetics & Toiletries: In order to meet the demands of the cosmetics sector, the manufacturer offers colors that are utilized in the production of lip color and other products. Lake colors are primarily utilized in these hues. As the highest quality raw materials, these hues are created. To accommodate the particular requirements of customers, these hues are modified (John *et al.*, 2022; Sulakvelidze, 2013).

Identification of Food colors in the several products

In 2016, supermarkets and small- and medium-sized vendors in Colombo, Sri Lanka, provided 120 samples of various food products. The samples were examined by using Thin - layer chromatography and UV Spectrophotometric methods, both of which are approved by Sri Lanka's Food Act rules.

The findings of this study showed how frequently certain foods and beverages sold in the Colombo district use permissible colors as well as the indiscriminate usage of non-permitted colors. Around 85% of legal colors were present in the samples. Only 9.2% of the samples were free of synthetic color. However, Alizarin, which is not authorized, was present in 5.8% of the samples (Kumudu *et al.*, 2015).

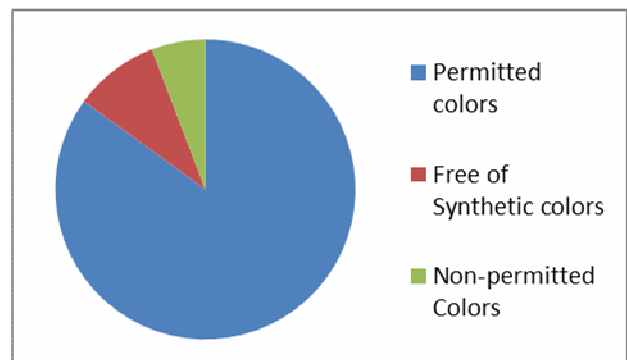


Fig. 2 : Distribution of artificial colors in samples of food and drink (The data presented is in percentage)

Thin layer chromatography

In TLC, the color specimens were each individually dissolved in distilled water. Then, samples were placed with standards at equal intervals between each point on a pencil line drawn parallel to the dish and 2 cm away from it on a TLC plate. For such, distinct, clean vials were adopted. Each patch was given about 5 minutes to dry before the next one was applied. Next, n-Butanol was used to run the chromatogram in a saturated chromatogram jar, after that the sample is taken out from the jar and allow it to get dry. This helps in finding the added colors in the food items (Kumudu *et al.*, 2015).

UV-Spectrophotometer

Using a spectrophotometric approach to determine the concentration of food dyes is one of the popular ways to guarantee the finest quality of the dyes. As chemical compounds are used to create food dyes, spectrophotometry is crucial to determine the proportion of each molecule so that no compound is present in the dye at a risky level. Additionally, testing food dyes with portable spectrophotometers ensures that the color level supplied to the food stuffs is at the ideal level.

The sample is exposed to a polychromatic light source via the spectrophotometer. This light is subsequently divided into some parts that fall within the visible region of the spectrum after being reflected from the substance. Now that the data has been quantified, the sample's color quality may be measured (*Spectrophotometers for Food Dye Analysis*, n.d.).

The TLC method was primarily utilized to identify the artificial colors that were added to the food kinds that were sampled, and the UV-spectrophotometric approach was then used to validate the presence of colors that were not permitted (Kumudu *et al.*, 2015).

Conclusion

This study found that using food coloring in canned and packaged foods in excess can have a number of dangerous impacts on people. As a result, a methodical approach must be used in the nation to demonstrate guidelines and restrictions to avoid the malpractice of adulterating food with synthetic colors, label the confections and beverages properly, control the guidelines of allowed synthetic colors, and ensure the safety and quality of food. In order to reduce the use of artificial dyes, it is required to increase oversight and ongoing control over the items that are supplied as well as to act harshly against any businesses that violate the law. Therefore, there is an urgent need to raise public knowledge regarding the use of artificial food coloring, its harmful consequences, and the health risks associated with its use in food products.

Recommendation

Consumers are leaning toward all organic-natural, chemical-free products and away from products with chemical additions. Increased public knowledge of the numerous health dangers caused by chemical chemicals rather than ingredients produced from plants is undoubtedly responsible for this trend. Due to the rising demand for organic colors from numerous end-use industries, including food & beverage, the global market for food colors is growing. By the end of 2030, the market is predicted to grow

to a size of more than USD 6.18 billion, as per a detailed research study by MRFR (*Food Color Market Size Worth USD 6.18 Billion by 2030 At*, n.d.).

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