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Mainak Debnath
Department of Applied Science and Humanities, Chemistry Section, Guru Nanak Institute of Technology 157/F Nilgunj Road, Panihati, Sodepur, Kolkata, West Bengal, India

Indrajit Bhattacharyya
Department of Applied Science and Humanities, Chemistry Section, Guru Nanak Institute of Technology 157/F Nilgunj Road, Panihati, Sodepur, Kolkata, West Bengal, India

Sreyasree Basu
Department of Applied Science and Humanities, Chemistry Section, Guru Nanak Institute of Technology 157/F Nilgunj Road, Panihati, Sodepur, Kolkata, West Bengal, India

Chandan Kumar Bhattacharyya
Department of Applied Science and Humanities, Chemistry Section, Guru Nanak Institute of Technology 157/F Nilgunj Road, Panihati, Sodepur, Kolkata, West Bengal, India

Corresponding Author:
Mainak Debnath
Department of Applied Science and Humanities, Chemistry Section, Guru Nanak Institute of Technology 157/F Nilgunj Road, Panihati, Sodepur, Kolkata, West Bengal, India

Food colour: Boon or Ban

Mainak Debnath, Indrajit Bhattacharyya, Sreyasree Basu and Chandan Kumar Bhattacharyya

Abstract
The present review summarizes the detrimental effects of synthetic colors and the beneficial role of naturally occurring colors on human health. It also aims to make people more conscious about the consumption of permitted synthetic colorants in food stuffs manufactured and sold by many food industries in India and the importance of replacement of artificial colors by naturally occurring dyes.
Human brain heavily relies on visual information, especially the color of the object, and thus the first impression and attraction towards anything, say food, is dictated by how it looks like. Food color is added in food stuffs for different reasons, such as, to replace the color loss during processing or to enhance the original color already used beforehand. Food colors can broadly be classified into two categories: natural colors and synthetic colors. Nature offers a wide range of colors suitable to be used as dyes in food stuffs in a limited way and thus natural colors have been used for centuries for imparting colors in foodstuffs. Moreover, the natural colors have well known antibacterial and anti-viral effects which in turn boost up our immune system. On the other hand, synthetic food colors are indigenously fabricated from coal tar, which found to be very stable under intense heat and light conditions. Though synthetic colors are widely popular in the food industries, they result in many detrimental health hazards particularly for children, such as, allergies, learning impairment, hyperactivity, impatience and some other assaultiveness. Popular uses of synthetic or artificial colors may also lead to risks which include memory loss, hypersomnia, depressions and allergic reaction in individuals with pre-existing asthma. Moreover, recurrent use of food products with color additives enhances the level of serum albumin and thus results in oxidation of fatty acids, reducing antioxidant enzymes in liver, acute inflammation and abstraction of kidneys etc. That is why the synthetic colors with permitted levels are being used in food and beverage industries over a decade, but it has also been found that the consumers have become more inclined towards consumption of foods containing naturally occurring colors. Nowadays, consumers are found to be more conscious and staying away from foods containing synthetic colorants.

Keywords: Natural colour, synthetic colour, natural colour's health benefit, health consequences of synthetic colours, limits of uses of synthetic colours

1. Introduction
Color plays an important role for foodstuffs since it sometimes guides to judge the food quality as well as brings in an aesthetic pleasure during consumption. That is why all the food processing companies and suppliers use their best expertise and put a lot of efforts to process and sell their food products with attractive colors. For millennia, naturally occurring colors, such as, paprika, turmeric, saffron, iron and lead oxides, and sulphates derived from different vegetables and mineral resources have been used as additives to impart colors in foods, drugs, and cosmetics. Egyptians first introduced artificial colors in cosmetics and hair dyes. In 1856, William Henry Perkin discovered the primary artificial organic dye, known as mauve [1]. "Coal-tar colors" which were first derived as the byproducts of coal process, became very popular and found to be useful in imparting colors in foods, drugs and essential cosmetics. In Europe the art of coloring was practiced throughout the Bronze Age. In Egypt the mummies are found wrapped with colored garments. Chemical analysis of red materials found within the topographic point of King Pharaoh in Egypt showed the presence of alizarin, a pigment extracted from madder. By fourth century AD, dyes like madder, wood and weld, indigo and dark empurpled were acknowledged. Use of naturally occurring bio-colorants in food was introduced by Japan during the eighth century when colored soybean and adzuki-bean cakes came into the market [2]. Since it used to be an essential criterion as well as a big challenge for all the food industries to draw the attention of consumers by offering attractively colored food stuffs, popular food coloring agents, such as, dyes, colors and pigments evolved gradually and the different sections of food manufacture started using them conventionally in a regular basis.

Due to the eco-friendly nature, anti-microbial and anti-oxidant activities [3], naturally occurring pigments, like turmeric powder, beetroot etc. (turmeric powder imparts yellow coloration, whereas, beet powder is used to impart red coloration) are found huge applications in food industries. That is why the demand for naturally occurring food colors is increasing day by day, which can provide good opportunities for brand spanking new entrepreneurs.

2. Natural food colors and their importance

Natural colors are also commonly known as "Bio Colors" as they are often derived from vegetables, fruits, roots and seeds, and sometimes extracted from microorganisms. Different plant pigments are extracted from edible plants and thus found to be harmless for our lives. Intensely colored fat-soluble pigments, such as, chlorophylls, carotenoids etc and water-soluble dyes, like, betanins, anthrocyanins etc are popularly being used as natural food colors [4].

Anthocyanins, which are a group of water-soluble pigments, are derived from vegetables and fruits, such as, black berries, cherries and grapes. UV-visible Spectroscopy reveals that Anthrocyanins absorbs light in between 250nm and 650nm. Thus, they impart red to blue color and the brightest color appears at around pH not more than 4 [5]. Various toxicology studies by The Food Safety and Standard Authority of India shows that anthocyanins are reliably safe to use as consumable food color [6]. That is why they have been sanctioned as legal food colourants [7, 8] and are widely used in popular desserts and beverages having pH less than 7.

Chlorophyll is another useful natural colorant, which is often used as an additive for food stuffs. For example, the vibrant green color of pasta and confections results from the addition of chlorophyll. On the other hand, it has been observed that air, light, heat, pH and temperature have negative impacts on the stability of commodities strained by chlorophyll. That is why in many cases, the products are packed in dark to evade chlorophyll disintegration resulting from atmospheric change and thus Chlorophyll finds limited application as a food color in industries.

Carotene is another class of natural compound that is responsible for bright coloration in various fruits and vegetables, such as, carrots, melons, oranges, tangerines, tomatoes and sweet potatoes etc. Moreover, it is used in low concentration to impart yellow color in food stuffs like margarine, butter, cakes, juice desserts etc.

2.1 Natural colour obtained from animals

Cochineal: Cochineal is a vermilion colored dye, derived from Cochineal bug, a scale insect that resides mostly on cactus. During the Pre Columbian era, Cochineal bugs were first discovered in India Female bugs were first dried in the sunlight and then they were crushed to get a fine powder [9], which used to contain Cochineal. Mostly it had been used to color yogurts, ice creams, frozen meat and fish.

Cyanobacteria: Cyanobacteria is a blue- green colored dye that is derived from the extract of Cyanobacteria spirulina. The demand of extracting blue color from spiraling increased day by day [10] once it started to be used widely in food industries.

Kermes: Kermes is a red colored dye, which finds huge demand in beverage industries. Kermes is extracted from an insect which is mostly found living on kermes oak tree[11]in Mediterranean region.

2.2 Health Benefits of Natural Colours

Naturally occurring food colors possess a couple of biologically active compounds with important medicinal properties, such as, anti-inflammatory, antioxidant, anti-carcinogenic and anti-arthritic effects [12-19] and thus play major roles in maintaining human health. Other health benefits of natural colorants include inhibition of certain mutagenic cells [20], building immunity power in our body[21] and protection from UV-ray [22].

Betacarotenes are rich sources of vitamin A, the deficiency of which causes night blindness. That is why consumption of carotene inhibits the deficiency of vitamin A.

Anthocyanins are also a group of flavonoids which have numerous health benefits such as treating cancers, lowering of high blood pressures, heart diseases etc. Recent studies reveal that regular intake of anthocyanin may reduce the chances to surpass cholesterol and thus reduces obesity and also helps in stress management.

Xanthophyllhas been proved to be a protective antioxidant for human retina [25-27] and boosts the eye sight by producing vitamin A turning aside cataracts, low visions, muscular degradation and glaucoma. Xanthophylls also act as a shield against ultraviolet damages.

Phenolic components like Flavonoids have anti-mutagenic and antioxidant properties [28] and thus brought multiple attentions due to preventive majors over various diseases. Moreover, Flavonoid has found to be very competent in reducing heart diseases like strokes and cardiomyopathy [29] that is why Flavinoids have been termed as one of the important semi essential foodsuppliments [30].

Chlorophylls are found to have anti-ageing properties. Health studies reveal that since chlorophyll helps to produce red blood cells [31], it is potentially helpful in the treatment of thalassemia and anemia. Chlorophylls are also proven to be very much effective in the treatment of colon cancers [32]. Some important natural food colors are listed in Table 1.

2.3 Synthetic colour

Synthetic colors or dyes being economically cheap, consistent and convenient to be achieved, paved food industries new avenues towards successful marketing of attractive colorful food products and maximization of their profits [33]. Additionally, these artificial colors impart enhanced brightness in colors and exhibit additional stability against the exposure of light [34] and strength in the coloring properties compared to that offered by naturally occurring dyes. Artificial food colors offer a wide range of color varieties, uniform color shades and variable flavors that make them popular among the confectioners. The recipes of confectionary items having bound shades utilize admixture dyes. For example, a combination of Tartrazine (yellow dye) and Orange I by a quantitative relation of eighty-five to fifteen results in "egg yellow" color, Tartrazine and Guinea Green B by a quantitative relation of ninety-seven to three, produces a "lime green" shade [35] etc. Supplementary colors or additives are often used by meat packers to sell their products looking natural and fresh, mostly for cured meat products, such as, bacon, sausages, and hams [36]. Having all of these positive aspects, synthetic food colors are often described to have detrimental health hazard issues and thus suggested to be prohibited over the years. Some commonly used synthetic food colors are mentioned in Table 2.

2.4 Limits of uses on synthetic color

Since it is mandatory to keep up a marginal convergence for any food additives, numerous regulations have been adopted over the years for the benefits of consumers throughout the world. Food colors can be broadly classified into categories: non permitted colors and permitted colors. Consumption of permitted color maximally limits up to 0.1 gm per kg as food additives [37]. The eight permitted synthetic food colors are mentioned in Table 3 [38].

2.5 Health Implication of synthetic colour

Artificial food colors are employed for making food stuffs more fascinating and attractive. Artificial food dyes are mainly manufactured from coal tar. These synthetic colors are widely used in food industries as well as pharmaceutical industries though the detrimental health hazards associated with the uses are quite well known. Dyes such as allura red and tartrazine, brown dye liberates histamine in human body and thus may elevate existing asthma problem. Recent studies have revealedthat [39] Yellow 5, Yellow 6, Red 40contain Benzedrine and other carcinogenic compound like 4-aminobiphenyl, which enhances the associated carcinogenicity. Different azo dyes such as ponceau, tartrazine, sunset yellow, amaranth also contains benzidine ring and create aromatic amines after metabolized by human body [40], which in turn, may lead to intestinal cancers. Metanil yellow is another widely used synthetic dye which shows certain symptoms like dizziness, vomiting and feebleness if consumed. It also damages kidney, liver and stomach. Consumption of artificial colors can thus cause hyperactivity among children, induce allergic reactions and significant depletion in IQ. Synthetic dyes like aura mine, rhodamine, malachite green, Sudan 3 are considered to be genotoxic. Sudan dyes are fat soluble, reddish brown colored diazo- synthetic dye which is now banned due to precarious effects on human body [41].

2.6 Colour adulteration in India [42]

Since a large portion of the consumers from our country are unaware and remain very indifferent about the health hazards resulting from the artificial food colors, color adulteration have found to be a quite well-known topic that has a profound impact on the food markets in India. Studies on food adulteration has revealed that dishes like rice pulav, halwa, jelebi and spices like turmeric, saffron, mixed spices are generally adulterated with a dye, commonly known as Metanil yellow. Again, Rhodamine B is used to enhance the color of red chili powder whereas Coal tar dye is used to impart color in butter.

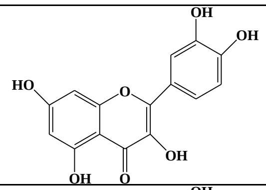
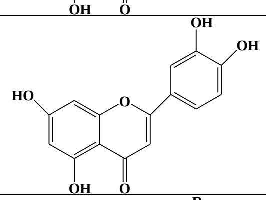
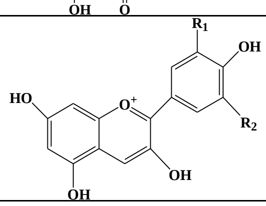
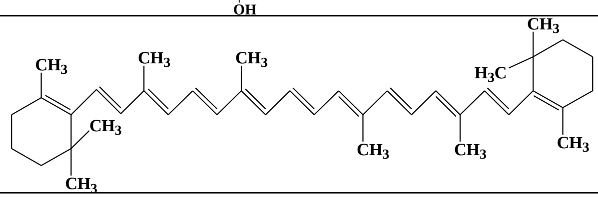
2.7 Technology used for identification of synthetic food colorant

A couple of popular technology based analytical methods, such as, traditional column chromatography, high performance liquid chromatography and high-performance thin layer chromatography are frequently used to detect and estimate the amount of non-permitted synthetic colorants which are often present in the food stuffs we commonly use in our day today lifey industry. As garlic contains a sulfur volatile active component that has antibacterial, anti-inflammatory and antioxidant biological properties (Wilson and Demming-Adams, 2007) [14], it has been explored as a potential alternative to antibiotics in poultry production. Garlic had been used worldwide to fight bacterial infections as it exhibited a broad antibiotic spectrum against both Gram positive and Gram negative bacteria.

Tulsi (*Ocimum sanctum*) is considered to be the "Queen of herbs" due to its greater medicinal values. Tulsi, known for its bactericidal, immuno-modulatory, narcotic, anti-inflammatory.

3. Tables, Figures and Equations

Table 1: Some important Natural Food Colors

Class	Example	E Number	Structure
Flavonoids	Quercetin		
	Luteolin		
Anthocyanidin	Pelargonidin (R1, R2=H) Cyanidin (R1=OH, R2=H) Delphinidin (R1, R2=OH)	E 163	
Terpenoid (Carotenoid)	Beta Carotene	E 160a	

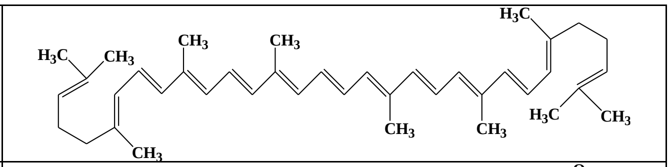
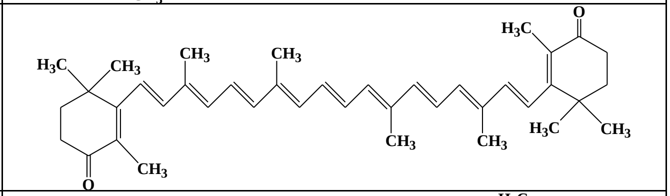
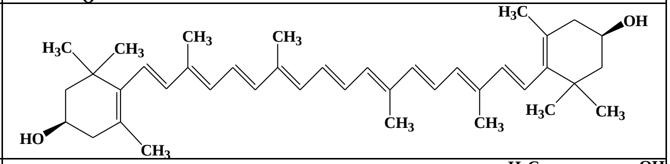
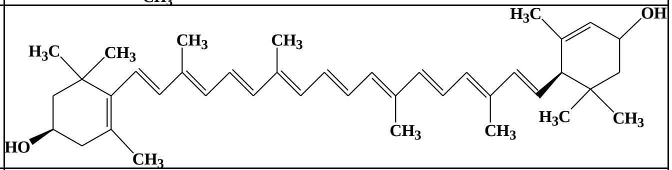
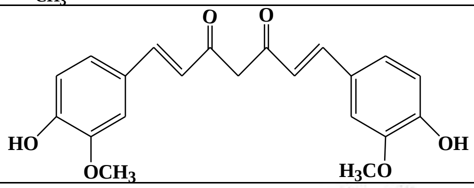
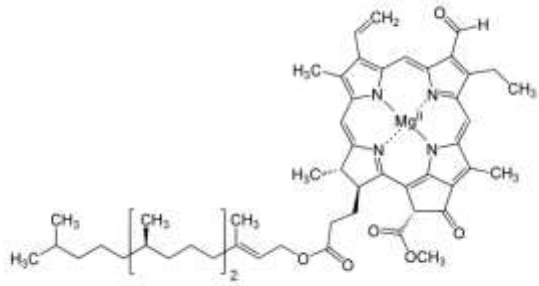
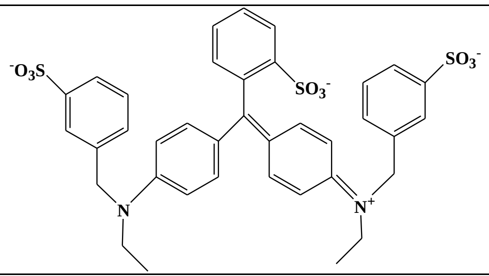
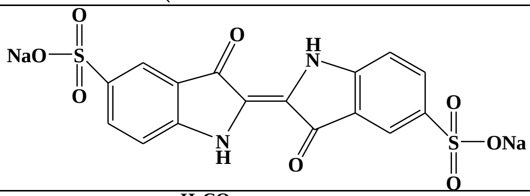
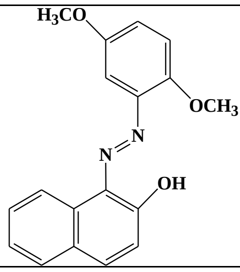
	Lycopene	E 160d	
	Canthaxanthin	E 160g	
	Zeaxanthin		
	Lutein	E 161b	
	Curcumin	E 100	
	Chlorophyll	E 140	

Table 2: Some commonly used synthetic food colours

Dye	Code	Structure
Brilliant Blue	Blue #1	
Indigo Carmine	Blue #2	
Citrus	Red #2	

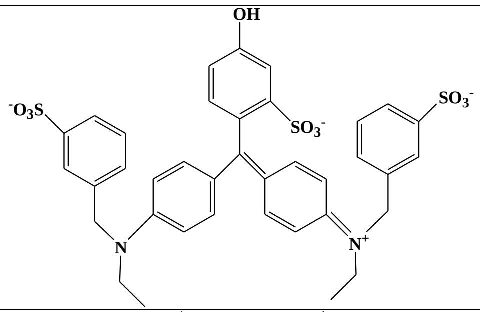
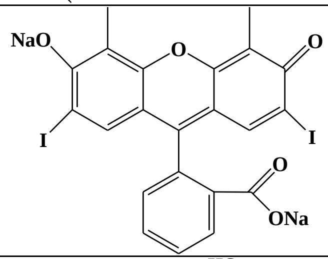
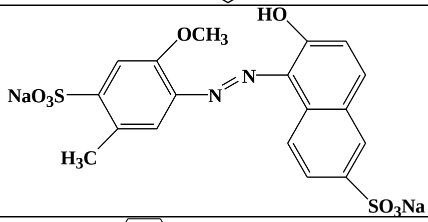
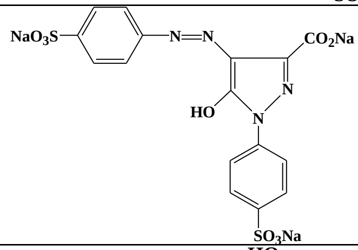
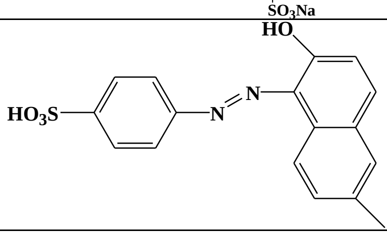
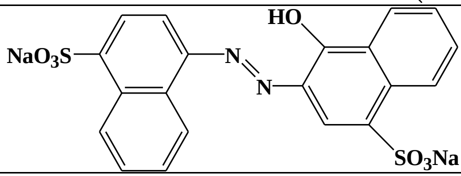
Fast Green	Green #3	
Erythrosine	Red #3	
Allura Red	Red #40	
Tartrazine	Yellow #5	
Sunset Yellow	Yellow #6	
Carmoisine	E122	

Table 3: Eight synthetic food colours which are reported as permitted colors as per Food Safety and Standard Authority of India act, 2006 [38]

SL. No.	Color	Common Name	Chemical Class
1	Red	Ponceau 4R	Azo
		Carmoisin	Azo
		Erythrosine	Xanthene
2	Yellow	Tartrazine	Pyrazolone
		Sunset Yellow FCF	Azo
3	Blue	Indigo Carmine	Indigoid
		Brilliant Blue FCF	Triarylmethane
4	Green	Fast Green FCF	Triarylmethane

4. Discussion and Conclusion

Changing lifestyles across the world have almost changed the aspects of food consumption patterns. The noticeable differences in this regard are found to be associated with fast urbanization and marked changes in social science like TV broadcasts encouraging and advertising lucrative food stuffs with colors added to them, and a huge demand on pre-cooked and pre-packaged foods that helps to save lots of energy and time. This sort of changes in our set of mind results in a noticeable profound transformation that brings in an exceptional advancement in the field of processed food and simultaneously affects the corresponding export markets. Thus, instant and readymade processed foods and such recent improvements of technological breakthrough within the food business have been provided uplift to the convenience which has governed to the employment of a range of food colors. As a result of hypersensitivity, carcinogenicity and allergic effects and alternative toxicological concerns, food dyes are thought to be harmful as before. We have a tendency to substantially advocate that food and drug restrictive agencies of various countries supposed to get up and illicit food dyes, which aid no purpose rather than a cosmetic result. To enhance the color and to draw the attentions of the customers, manufacturers often use artificial colors to food products. Thus, for the sake of the safety of the customers, is wise and at the same time mandatorily important to slowly phase out the utilization of artificial colors in food products. Consequently, there would be a great demand to replace synthetic food colors with bio-colors which have lots of health benefits including boosting our immunity. Thus, consumption of these natural dyes can also help us in combating with various diseases in post Covid-19 era. Meanwhile, food industries also should voluntarily replace artificial dyes with natural colorings, although it is very challenging due to expensive and unstable nature of the natural pigments. The present range of natural colours compare to artificial pigments also increases the challenge in next level. It is therefore important to find out new and novel bio-colors and pigment producing micro-organisms as well as to improve the technologies to make the production more cost effective.

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