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NATURAL FOOD COLOURS Vs SYNTHETIC FOOD COLOURS: A HEALTHY PERSPECTIVE

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ABSTRACT
The growing scientific evidence and increasing consumer awareness are driving a significant shift toward safer, plant-derived natural pigments as sustainable alternatives to synthetic food colorants. Collectively, emerging toxicological evidence and regulatory reassessments emphasize the urgent need to prioritize natural pigment-based colorants, not only to minimize potential health risks also also to promote sustainable and functional food systems.Moreover, the multifunctional properties of plant-derived pigments-including antioxidant, anti-inflammatory, and anticancer activities-position them as promising bioactive compounds that extend far beyond their traditional role as mere coloring agents. As consumer demand shifts toward clean-label and health-oriented products, the replacement of synthetic dyes with stable, cost-effective natural alternatives represents a critical direction for future food innovation and safety assurance.

Keywords: *Anthocyanins, carotenoids, colorants, dyes, food colour, flavonoids, natural colours, plant pigments, synthetic colours, toxicity.*

1. INTRODUCTION

Food properties, namely colours, which are a visual feature associated with the spectral distribution of light resulting from the interaction with matter, largely determine consumer's satisfaction and expectations, affecting their choice and eating desires. Food colours affect recognition and product acceptability (warning consumers against eating spoiled food which is hazardous to health), as they are a beam of sensory perceptions such as sight, smell, and taste [1]. Still, the degradation of existing natural pigments can prevail during food processing, which in most cases requires addition of colourants to restore or enhance colour. Thus, a large number of food products incorporate colours in order to obtain a pleasing appearance or dye feature. For instance, in order to enhance consumers preferences, food colours are usually applied to edible ices, desserts, pastry and fine bakery products, decorations and the coatings of pastry, confectionary products, sauces, fruit juices, snacks and soft drinks, and alcoholic beverages [2-3]. Food colours can be synthetic, synthesized equally to the natural, or naturally derived. Although most of the natural food colours are derived from plants, some others are obtained from animals or even ores.

2.FOOD COLORANTS

Food colorants are additives (natural or synthetic) used to enhance appearance, maintain consistency, or add colour to food products. They include natural pigments like carotenoids (orange) and chlorophyll (green), as well as synthetic dyes like Allura Red and Tartrazine. These substances improve consumer perception and replace colour lost during processing. Making food more attractive, appealing, or appetizing. Offsetting colour loss over time due to exposure to light, air, temperature extremes, moisture, or storage conditions

- Stabilizing natural variations in colour
- Enhancing colours that occur naturally
- Providing colour to colourless or "fun" foods

Allowing products to be identified via sight, such as candy Flavors or medicine dosages.

3.SYNTHETIC VS NATURAL FOOD COLORS

Synthetic food colours, on the other hand, are artificially created in laboratories using chemical compounds. These colours are often more vibrant and stable than their natural counterparts, making them a popular choice for the food industry. Synthetic food colours are typically available in liquid, powder, or gel form and can be easily mixed to achieve the desired shade. Some well-known synthetic food colours include Tartrazine (Yellow #5), Red 40, and Blue 1, which are often denoted by n. Synthetic food colours are composed of artificial chemical compounds, which may include coal-tar derivatives and petroleum-based chemicals. Some of these synthetic colours have raised concerns about potential health risks when consumed in large quantities

1. Source

Natural Food Colours: As the name suggests, natural food colours are sourced from plants, fruits, vegetables, and other natural ingredients. They are minimally processed and are generally considered safe for consumption.

Synthetic Food Colours: Synthetic food colours are chemically synthesized in laboratories. They do not originate from natural sources and are created through a series of chemical reactions.

2. Chemical Composition

Natural Food Colours:The pigments in natural food colours are composed of naturally occurring compounds, such as chlorophyll, carotenoids, and anthocyanins. These compounds are often rich in antioxidants and can have additional health benefits.

Synthetic Food Colours: Synthetic food colours are composed of artificial chemical compounds, which may include coal-tar derivatives and petroleum-based chemicals. Some of these synthetic colours have raised concerns about potential health risks when consumed in large quantities.

Chemical structures of representative natural colorants Food colorants, natural

Chemical structures of representative artificial colorantsFood colorants, synthetic.

4.TOXICITY AND EVALUATIONS OF SYNTHETIC AZO DYES

1.Toxicity Evaluation of Azo Dyes ,The following is an overview of the toxicity of individual synthetic colors approved in the an overview of their chemical structures current ADIs.

2.1.E104 FLAVUM QUINOLINI, Quinoline Yellow

Quinoline Yellow is one of the colours raising the greatest health concerns, including about the potential effects on children's behaviour. this evaluation ,in which the ADI was l owered from 10mg/kg to the current 0.5mg/kg. The panel warned that the actual consumption of the color additive usually exceeds the new ADI value, with at heoretical maximum daily exposure of 8.1mg/kg/day for adults and 13.1mg/kg/day for 3-year old children.

2.2. E 110 FLAVUM ORANGEATUM, Sunset Yellow

Multiple authorities have evaluated the toxicity of Sunset Yellow because of concerns about its wide use in the culinary and pharmaceutical industries. The additive can cause the release of histamine, potentially triggering various allergies and intensifying symptoms of asthma . In 2009, the EFSA established a temporary ADI of 1 mg/kg of body weight per day; however, this temporary ADI was revised in 2014, establishing a new ADI of 4 mg/kipper day .

5.PLANT NATURAL PIGMENT COLORS

Natural food colours or biological pigments originate from a wide range of sources like vegetables, fruits, plants, minerals and other edible natural sources .There are four families of plant pigments . Major plant pigments include, Chlorophyll (green), Carotenoids (yellow, red, orange), Flavonoids: anthocyanins, canthaxanthins (red, blue, purple), and Betaines (red, yellow, purple) .Fruits and vegetables are colourful pigment-containing food sources . Owing to their nutritional benefits and phytochemicals, they are considered as 'functional food ingredients.

1) Green colour: Chlorophyll

A water-insoluble plant pigment, primarily responsible for the green colour of all green vegetables and fruits like spinach, fenugreek leaves, coriander leaves, bell peppers, broccoli, green cabbage, celery, green beans, turnip greens, green chilies etc .

2) Red colour: The betaines

(betacyanin) and yellow to orange (betaxanthin) pigments.Carotenoids (lycopene, canthaxanthin, and astaxanthin), anthocyanins, and betacyanin's are natural red pigments found in fruits and vegetables like tomatoes, guava, red grapefruit, papaya, rosehips, and watermelon indicate the presence of lycopene . Cranberry, beet, watermelon, tomato, strawberry, pomegranate are some of the most commonly available red plant foods .

3) Yellow/ Orange colour

Carotene: Carotenoids are the lipid soluble pigment compounds that impart yellow and orange colours to fruits and vegetables . These are the most widely distributed pigments in the plant kingdom . Carotenoids are basically classified into two types: Carotenes, which contain no oxygen, and Xanthophylls, which contain oxygen . Carotene absorbs blue and indigo hues, that provides rich yellows and oranges to different foods.

6. PLANT NATURAL PIGMENTS: HEALTH BENEFITS

A study has been reported that chlorophyll-rich plant extracts like wheat grass and other green vegetables can inhibit the cancer-causing effects of two mutagens (benzopyrene and methylcholanthrene). The structural resemblance of haemoglobin with chlorophyll makes to restore the RBCs and enhances their ability to carry more oxygen as well as eliminate the factors responsible for anaemia. Furthermore, dietary chlorophyll and its derivatives prevalent in both fresh

and processed foods have antioxidant and antimutagenic activities. In addition to this chlorophyll stops bacterial growth in wounds, eliminates bad breath and body odour. Chlorophyll also helps to remove heavy metals from the body that have accumulated due to the ingestion of contaminated food products [4].

It has also been reported that Resveratrol has several neuroprotective roles in various neurodegenerative impairments, such as Alzheimer's, Huntington's, Parkinson's diseases, amyotrophic lateral sclerosis and alcohol-induced neurodegenerative disorders Certain laboratory studies have shown red coloured apples containing a variety of phytochemicals, including quercetin, catechin, phlorizin and chlorogenic acid have strong antioxidant activity, inhibited cancer cell proliferation, decreased lipid oxidation, and lowered cholesterol.

Three of the most common carotenoids-alpha carotene, beta carotene and beta-cryptoxanthin -can be converted from foods into vitamin A in the body . Vitamin A is needed for good vision in dim light, normal growth and development, a strong immune system and to keep the skin and cells that line the airways, digestive tract and urinary tract healthy . There's also evidence to suggest that carotenoids-and especially beta carotene, might help to reduce the risk of heart disease and certain cancers, especially lung cancer.Citrus fruits and their juices are also packed with the phytochemical hesperidin, (protect against heart disease) and tangerine (may prevent cancer of the head and neck) . It has been found that the zest of yellow citrus fruits is also a good source of limonene, a phytochemical that helps keep lungs healthy.

6.DEFECTS OF SYNTHETIC COLOURS

Synthetic colours, widely used in food, cosmetics, and textiles for their vibrant and low-cost nature, are associated with several significant health and environmental defects. Derived from petroleum or coal tar, these artificial compounds are primarily designed to enhance appearance and provide no nutritional value.

Health Defects and Risks

Neurobehavioral Issues in Children: Numerous studies link synthetic dyes (e.g., Red 40, Yellow 5, Yellow 6) to increased hyperactivity, inattentiveness, and restlessness in children, regardless of whether they have ADHD.

Carcinogenic Potential: Some dyes are suspected of being carcinogenic. For instance, Red 3 has been identified as a cause of thyroid tumours in rats, leading to bans in certain applications. Other dyes like Sudan dyes (used illegally in food) are known carcinogens.

Allergic Reactions and Sensitivities: Synthetic colours, particularly Tartrazine (Yellow 5) and Sunset Yellow (Yellow 6), are known to trigger allergic reactions, including hives, itching, and asthma in sensitive individuals.

Environmental Defects

Water Pollution: The manufacturing process for synthetic dyes often involves toxic chemicals, and untreated effluent dumped into water bodies causes severe pollution, accounting for roughly 20% of industrial water pollution.

Non-Biodegradability: Many synthetic dyes are resistant to degradation, leading to long-term environmental contamination and disruption of aquatic ecosystems.

7.INDIAN PRESERVATION OF FOOD ADULTRATION ACT 1954

In India, the Prevention of Food Adulteration Act, 1954 (now called the Food Safety and Standards Act, 2006), has been implemented for the quality assurance of various types of foods and food products . Further, only eight dyes have been suggested edible, but within prescribed limits . This act recognizes eight coal tar dyes as safe for use in foods and cosmetics . As far as the usage of food dyes in other countries is concerned, authorities allow only 7 dyes in the United States of America, 8 in Canada, and 15 in several European countries . According to the Indian PFA/FSSA, eight synthetic dyes which are allowed to be used as red, yellow, blue and green colours in food are – Brilliant Blue FCF (Blue 1), Indigo Carmine (Blue 2), Fast Green FCF (Green 3), Tartrazine (Yellow 5), Sunset Yellow FCF (Yellow 6), Erythrosine (Red 3), Carnosine (Red 10) and Ponceau 4R (Red 18) .

1)Tartrazine

Tartrazine is a synthetic lemon-yellow Azo dye used as a food colour . Azo food colours are synthetic, and are prepared from aromatic amines, which contain an Azo group of two nitrogen atoms linked together (-N = N-) and linked to aromatic rings The azo food colours usually have a yellow, red or brown colour .

2)Quinoline Yellow

The food colouring quinoline yellow belongs to the class of quinethazone dyes .This colourant consists of a mixture of colours of synthetic origin derived from the quinolone . Quinoline yellow is a yellow powder or granule, owing to the presence of sulfonate groups, which is soluble in water and sparingly soluble in ethanol. It is a mixture mostly of disulfonates, but it also has Mon sulfonates and Tri sulfonates of 2-(2-quinolyl) indan-1,3-dione .This additive is usually a sodium salt, but potassium and calcium salts are also permitted [5].

3) Sunset Yellow FCF

The food colouring Sunset Yellow FCF is a petroleum derived orange Azo dye ($C_{16}H_{10}N_2Na_2O_7S_2$) that gives a yellow orange colour to food products . Sunset Yellow FCF is an orange red powder or granule, which is soluble in water and sparingly soluble in ethanol .Like other Azo food colours, Sunset yellow-orange is usually present as a sodium salt, but potassium and calcium salts are also allowed [6].

4) Azorubine

The food colouring azorubine is an Azo dye consisting of two naphthalene subunits ($C_{20}H_{12}N_2Na_2O_7S_2$) .This synthetic food colour gives a red colour to

foodstuffs.This colorant is soluble in water slightly soluble in ethanol solution, but insoluble in vegetable oil .Due to the general stability of Azo dyes, Azorubine is pH and heat stable, and it does not fade away when exposed to light and oxygen . It is mainly used in foods that are heat-treated after fermentation, occurs as red to maroon powder or granules, and is soluble in water and sparingly soluble in ethanol. Azorubine has been used in a large number of foodstuffs, namely flavoured drinks, fruit syrups, canned red fruits, ice creams, flavoured fermented milk products, edible ices, desserts, pastry and fine bakery products, confectionery including breath refreshing and chewing gum, soups, sauces, seasoning, seafood, fish roe, fish paste and crustacean paste, precooked crustaceans, appetizers and alcoholic beverages [7-8].

5) Erythrosine

Erythrosine ($C_{20}H_6I_4Na_2O_5H_2O$) is a xanthene dye (thus, it is not an Azo substance). It is a red food colouring of synthetic origin . Erythrosine is a disodium salt of 2,4,5,7- tetraiodofluorescein is a red powder or granule which is soluble in water and slightly soluble in ethanol.

6) Allura Red AC

Allura red AC, is a synthetic red Azo food colouring with the chemical formula $C_{18}H_{14}N_2Na_2O_8S_2$ .Although it is usually supplied as a sodium salt, it can also be used in the form of calcium and potassium salts .This food colour which takes the form of a dark-red powder or granule, is soluble in water but insoluble in ethanol.This additive is used in decorations and coatings for pastry products, confectionery including breath refreshing and chewing gum, pastry and fine bakery products, flavoured fermented milk products, edible cheese rinds, desserts, preserves of fruits, ice cream, flavoured drinks, baked crustaceans, seafood, breakfast sausages, appetizers, sauces, seasonings, soups,luncheon meat, replacements, and alcoholic beverages [9].

8.RECENT FOOD COLOURS

"clean label" alternatives. Key developments include Butterfly Pea Flower Extract (bright blue/purple), Galdieria Extract (blue), Beetroot Red, and Calcium Phosphate (white). These options replace synthetic dyes, offering stable, vibrant options for beverages, confectionery, and dairy.

Key Recent Developments in Food Colors

Natural Blue/Purple/Green: Butterfly Pea Flower Extract provides versatile shades from blue to green and is approved for use in diverse products like dairy, candies, and beverages. Galdieria blue (algae-derived) is another significant new natural blue.

Natural Red: Beetroot Red has been highlighted as a new natural red dye, enabling "no artificial colors" labeling.

Regulatory Focus: The FDA and EFSA continue to monitor and, in some cases, re-evaluate or approve new natural sources to replace artificial ones.

Other Key Natural Trends: Anthocyanins (purple/blue/red), Betalains (pink/red), and Carotenoids (yellow/orange) are widely used for clean-label formulation [10].

7.LIMITATIONS AND CHALLENGES

limitations and challenges regarding synthetic food colors in India include

Usage of Non-Permitted Dyes: Despite regulations, banned, toxic dyes like Rhodamine B and Metanil Yellow are frequently used in street foods, snacks, and sweets, posing severe health risks like cancer, liver damage, and allergic reactions [11].

High Consumption & Overuse: Permitted synthetic colors (e.g., Tartrazine, Sunset Yellow FCF) are often used in excess of the prescribed .100 ppm limit.

Health Hazards: Evidence links synthetic colors to increased hyperactivity and attention deficit disorders (ADHD) in children. Other risks include asthma, migraines, and long-term cancer risk [12].

Low Consumer Awareness: Consumers often fail to check labels for, or are unaware of the risks associated with, synthetic additives.

Challenges for Manufacturers: Local manufacturers struggle with compliance when exporting, as many synthetic dyes permitted in India are banned or strictly regulated in the West [13].

Environmental Impact: Synthetic dyes are largely non-biodegradable, posing, high, toxic, and environmental risks.

Behavioral Issues in Children: Multiple studies link artificial dyes (e.g., Red 40, Yellow 5) to hyperactivity, irritability, and attention deficits.

Allergic Reactions: Consumption can trigger hypersensitivity, asthma, and skin rashes.

Carcinogenicity and Toxicity: Some dyes, such as Red 3, are linked to cancer, while others may contain carcinogens like benzene.

Long-Term Health Risks: Regular consumption is associated with potential immune system disruption, inflammation, and metabolic issues [14.

Consumer Shift to Natural: Growing preference for natural colors, forcing manufacturers to reformulate, although natural alternatives can be less stable.

9.CONCLUSION

The increasing variety of food production, which is associated with the diversification of technological developments and changes in consumers' nutrition habits, has increased the number of processed foods. In this context, the colouring additives applied to food products play an important role in consumers' preferences. However, their preferences for naturally derived colourants which are closely associated to the image of healthy, safe and good-quality products sharply increased, as a large number of synthetic dyes have recognized side effects on human health. Synergistic effects and multiple functions simultaneously are common in natural additives; however, some may be incompatible with others,

natural or artificial, as well as with the constituents of food itself, so that their use may be impeded. Despite the described limitations, additives of natural origin are believed to be the future of food preservation allowing shelf life extension and preventing food loss. We reviewed new lines of evidence regarding the azo dyes used as food colors. However, their preferences for naturally derived colourants-which are closely associated to the image of healthy, safe and good-quality products-sharply increased, as a large number of synthetic dyes have recognized side effects on human health. Thus, considering the challenge imposed to the food industries, in order to surpass the technological limitations imposed by richly coloured pigments due to their properties/abilities (i.e., the chemical stability of naturally derived food pigments that is affected pH, temperature, light, oxygen, solvents, enzymes.

10.AUTHOR CONTRIBUTIONS

All authours are contributed equally.

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The authors have no conflicts of interest to declare.

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14.REFERENCES

1. Lidon FJ, da Silva Ferreira MM. Indústrias alimentares: aditivos e tecnologia. Lisboa: Escolar Editora; 2007.
2. Saltmarsh M. Food additive regulations in Europe. In: Branen AL, Davidson PM, Salminen S, Thorngate J, editors. Food additives. New York: CRC Press; 2001.
3. Lidon F, Silvestre MM. Princípios de alimentação e nutrição humana. Lisboa: Escolar Editora; 2010. p.176-178.
4. Gindi S, Methra T, Chandu BR, Boyina R, Dasari V. Antiurolithiatic and in vitro antioxidant activity of leaves of *Ageratum conyzoides* in rat. World J Pharm Pharm Sci. 2013;2:636-649.
5. Rambler RM, Rinehart E, Boehmler W, Gait P, Moore J, Schlenker M, Kashyap R. A review of the association of blue food coloring with attention deficit hyperactivity disorder symptoms in children. Cureus. 2022;14(9):e29204. doi:10.7759/cureus.29204.
6. Nama S, Chandu BR, Awen BZ, Khagga M. Development and validation of a new RP-HPLC method for the determination of aprepitant in solid dosage forms. Trop J Pharm Res. 2011;10(4):489-495. doi:10.4314/tjpr.v10i4.10.
7. Kiranmai M, Renuka P, Brahmaiah B, Chandu BR. Vitamin D as a promising anticancer agent. Int J Pharm Sci Rev Res. 2011;7(1):1-6.
8. Chen N, Watanabe K, Kobayakawa T, Wada M. Relationships between autistic traits, taste preference, taste perception, and eating behaviour. Eur Eat Disord Rev. 2022;30(5):628-640. doi:10.1002/erv.2947.
9. Cruz S, Lifter K, Barros C, Vieira R, Sampaio A. Neural and psychophysiological correlates of social communication development: Evidence from sensory processing, motor, cognitive, language and emotional behavioral milestones across infancy. Appl Neuropsychol Child. 2022;11(2):158-177. doi:10.1080/21622965.2020.1824455.
10. Renuka P, Brahmaiah B, Chandu BR. Vitamin D as a promising anticancer agent. Int J Pharm Sci Rev Res. 2011;7(1):1-6.
11. Miller MD, Steinmaus C, Golub MS, Castorina R, Thilakartne R, Bradman A, Marty MA. Potential impacts of synthetic food dyes on activity and attention in children: A review of the human and animal evidence. Environ Health. 2022;21(1):45. doi:10.1186/s12940-022-00847-1.
12. Branen AL, Davidson PM, Salminen S, Thorngate J, editors. Food additives. 2nd ed. New York: CRC Press; 2001.
13. Sarvani V, Elisha RP, Nama S, Pola LM, Rao CB. Process validation: An essential process in pharmaceutical industry. Int J Med Chem Anal. 2013;3(2):49-52.
14. Nama S, Chandu BR, Awen BZ, Khagga M. Development and validation of a new RP-HPLC method for the determination of aprepitant in solid dosage forms. Trop J Pharm Res. 2011;10(4):489-495. doi:10.4314/tjpr.v10i4.10.