

## **Hidden Hues: A Review on the Implications of Colour Adulterants in Food**

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### **Abstract**

Food is considered as the fundamental requirement of living beings and is crucial for ensuring optimal nutrition for human kind. The act of eating foods can lead to pleasure and satisfaction for humans. Thus, appearance of food is an important aspect that makes it attractive to various age group of people and can be a source of joy. Food colorants are often used to enhance the aesthetic appeal of foods. Although, there are reports on using adulterants as food colorants that might cause harmful health impacts. Any foods must be free of any contaminants ensuring the consumer safety. In this context, the present study aims to identify the harmful colour additives used in food products and also to investigate the methods of detections of these colorants. This review also focuses on the health impacts of using unauthorized and harmful colour additives. Food safety detection methods, including home-based tests along with advanced analytical techniques, are also discussed. The study emphasizes on the importance of strict quality control and ethical procedures in ensuring food safety and consumer health by addressing the hidden threats of colour adulterants.

**Keywords:** Food Colorants, adulteration, food safety, synthetic colours, health hazards, quality control.

## **Introduction**

Color is an essential sensory attribute for food which often serves as a critical indicator of quality, appeal and freshness. There is a human tendency to associate vibrant colors with taste and nutritional value which has led food manufacturers to rely heavily on colorants to enhance the visual appeal of their products. However, not every colorants used in the food industry are safe for human.

The deliberate or accidental incorporation of non-permitted or excessive amounts of permitted colour additives are referred as colour adulteration, poses significant risks to consumer health. These hidden hues, though visually appealing, often conceal a spectrum of harmful effects ranging from mild allergic reactions to severe chronic conditions such as organ toxicity and carcinogenicity.

The practice of food adulteration, including the use of unauthorized colorants, is often driven by economic motives. Adulterants can mimic the appearance of high-quality ingredients at a fraction of the cost, thus enabling unscrupulous manufacturers to increase profits. Unfortunately, these practices are not limited to developing nations; they are a global concern, affecting both local and international markets. It is important for the consumer to be aware of common adulterants and their effect on health (Acharya and Shah, 1999). In response, regulatory agencies worldwide have established stringent standards for the use of food colorants. Yet, the prevalence of adulterated food products suggests lapses in enforcement and public awareness.

## **Food Colourants**

Food colorants are substances added to food and beverages to impart or enhance color, making

them visually appealing to consumers. They play a crucial role in food presentation and perception, influencing consumer preferences and purchasing decisions. Food colorants can be classified into two main categories: natural and synthetic.

### **Natural Food Colorants:**

1. Carotenoids: Naturally occurring pigments found in fruits, vegetables, and other plant based foods. Examples include beta-carotene (orange), lycopene (red), and lutein(yellow).
2. Anthocyanins: Water-soluble pigments responsible for the red, purple, and blue colors in fruits, vegetables, and flowers. Examples include cyanidin (purple), delphinidin (blue), and
3. Chlorophyll: The green pigment found in leafy green vegetables, algae, and some herbs.
4. Betanin: A red pigment extracted from beets, betanin is commonly used as a natural red food colorant in various food products.
5. Annatto: Derived from the seeds of the achiote tree, annatto is used as a natural yellow to orange food colorant in cheese, butter, and other dairy products.
6. Turmeric: A spice derived from the rhizomes of the turmeric plant, turmeric contains the yellow pigment curcumin and is used as a natural food colorant.

### **Synthetic Food Colorants:**

1. FD&C Dyes: Synthetic colorants approved for use in food and drugs by the U.S. Food and Drug Administration (FDA). Examples include FD&C Red No. 40 (Allura Red AC), FD&C Yellow No. 5 (Tartrazine), and FD&C Blue No. 1 (Brilliant Blue FCF).
2. Lake Colors: These are water-insoluble forms of synthetic dyes, formed by combining the dye with an insoluble base. Lake colors are used in products where water solubility is not required, such as coatings, confections, and oil-based products.



**Figure1:** Shades of synthetic food colour

The European Food Safety Agency (EFSA) of the European Union (EU) and the Food and Drug Administration (FDA) of the United States of America are the two primary regulatory bodies in the world for food additives. These institutions carry out safety regulations, review scientific data, assess potential toxicity, and estimate human dietary exposure to food additives. Beyond just naming them, the EFSA gives each food additive a special identification code made up of the letter “E” and a number. Colours range from E100 (Curcumin) to E180 (Litholrubine BK). Artificial food colours are restricted by the Regulation (EC) 1333/2008. Only those colors listed in Annex II (European Commission, 2011) are authorized for foods. Permitted food colour by **FSSAI (India):** *Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011*

**Table 1: Permitted food colours with their shade, dosage and usage by EU**

| E-Number | Name             | Color Shade   | Maximum Permitted Dosage | Commonly Used In                      |
|----------|------------------|---------------|--------------------------|---------------------------------------|
| E 102    | Tartrazine*      | Bright Yellow | 100 ppm                  | Soft drinks, chips, pickles, desserts |
| E 104    | Quinoline Yellow | Yellow        | 50-300 ppm (EU limit)    | Candy, soft drinks, jelly             |

|        |                                     |            |                                      |                                        |
|--------|-------------------------------------|------------|--------------------------------------|----------------------------------------|
| E 110  | Sunset Yellow FCF / Orange Yellow S | Orange     | 100 ppm                              | Juices, ice cream, bakery products     |
| E 122  | Azorubine, Carmoisine*              | Red        | 100 ppm                              | Jellies, jam, sweets, beverages        |
| E 123  | Amaranth*                           | Dark Red   | 30-50 ppm (Banned in some countries) | Wine, soft drinks, cake decorations    |
| E 124  | Ponceau 4R, Cochineal Red A*        | Red        | 100 ppm                              | Candies, drinks, bakery products       |
| E 127  | Erythrosine                         | Pink       | 100 ppm                              | Candies, icing, jellies                |
| E 129  | Allura Red AC*                      | Red        | 100 ppm                              | Soft drinks, dairy products, snacks    |
| E 131  | Patent Blue V                       | Blue       | 100 ppm                              | Sweets, drinks, ice cream              |
| E 133  | Brilliant Blue FCF                  | Blue       | 100 ppm                              | Confectionery, soft drinks, ice creams |
| E 142  | Green S                             | Green      | 100 ppm                              | Canned vegetables, soft drinks         |
| E 151  | Brilliant Black BN, Black PN*       | Black      | 100 ppm                              | Licorice, sauces, candies              |
| E 154  | Brown FK*                           | Brown      | 50-200 ppm (Restricted)              | Smoked fish, meat products             |
| E 155  | Brown HT*                           | Brown      | 100 ppm                              | Chocolate, sauces, cereals             |
| E 160e | Beta-apo-8'-carotenal (C30)         | Orange-Red | 50 ppm                               | Margarine, dairy, sauces               |
| E 180  | Litholrubin BK*                     | Red        | 100 ppm                              | Cheese rind coloring                   |

While both natural and synthetic food colorants are regulated by food safety authorities, concerns have been raised about the safety of some synthetic colorants, particularly in sensitive individuals or when consumed in large quantities. As a result, demand increases for natural food colorants derived from plant-based sources, driven by consumer preferences for clean-label products and concerns about synthetic additives. Regulatory agencies continuously assess the safety of food colorants and establish maximum permitted levels to ensure consumer safety.

### Cause Of Colour Adulteration

Contamination or adulteration in food is added due to

various reasons which includes financial gain, carelessness and lack in proper hygienic condition of processing, storing, transportation and selling. Therefore, the consumer is either fooled or usually become victim of diseases (Abraham *et al.*, 1997). The growing demand for food products, coupled with supply shortages, often leads to the use of synthetic chemicals, artificial colors, and harmful preservatives to maintain product availability. The consumer preference for lower-priced products also plays a role, as the demand for inexpensive food encourages the use of substandard ingredients and adulterants

### **Common Food Items With Colour Adulterant And Their Detection Test**

#### **1. Milk**

ADULTERANTS- metanil Yellow

METHOD OF DETECTION- To 10 ml milk in a test tube, add 10 ml diethyl ether and shake vigorously. Add a few drops of Concentrated HCl. Observe the color change in ether layer

INFERENCE- No change in color of ether layer indicates the absence of Metanil yellow and Pink to dark red color indicates the presence of Metanil yellow.

#### **2. Ghee, Butter, Khoa, Cheese, Condensed Milk, Milk Powder**

ADULTERANTS- Coal Tar Dyes

METHOD OF DETECTION- Take one full teaspoon (2 ml) of melted sample in a test tube . Add 5 ml of concentrated HCl or dilute H<sub>2</sub>SO<sub>4</sub>.

INFERENCE - Appearance of pink color with Dilute H<sub>2</sub>SO<sub>4</sub> or crimson red color with concentrated HCl indicates the presence of coal tar dyes

#### **3. Pulse**

ADULTERANTS- Metanil Yellow

METHOD OF DETECTION- Take one g of the pulse/food in a test tube and add luke warm water to bring in solution . Add a few drops of concentrated HCl. Observe the change in

color

INFERENCE – The immediate development of pink color indicates the presence of metanil yellow dye.

#### **4. Ragi**

ADULTERANTS- rhodamine B

METHOD OF DETECTION- Take cotton ball soak with vegetable oil. Rub on the surface of ragi

INFERENCE- if cotton ball absorbs the colour then it is adulterated

#### **5. Chilli powder**

ADULTERANTS- Rhodamine-B

METHOD OF DETECTION- Take 2 grams sample in a test tube. Add 5 ml of acetone. Observe color of acetone layer

INFERENCE – Immediate appearance of red color indicates presence of Rhodamine-B

ADULTERANT- Sudan red III

METHOD OF DETECTION- Take one g of chilli powder in a test-tube. Add 2 ml of hexane to test tube, and shake well. Decant the clear solution into another test tube. Add 2 ml of acetonitrile reagent and shake well. Observe color of lower acetonitrile layer

INFERENCE-The appearance of a red color in the lower acetonitrile layer indicates the presence of Sudan red III.

ADULTERANTS- Oil soluble colour

METHOD OF DETECTION- Take 2 g of the sample in a test tube, add few ml of ether and shake. Decant ether layer into a test tube containing 2 ml of dilute HCl (50%) and shake. Observe the color of lower acid layer

INFERENCE – Red color of the lower acid layer indicates the presence of oil soluble color.

#### **6. Turmeric Powder**

ADULTERANTS- lead chromate

**METHOD OF DETECTION-** Ash about 2 grams the sample. Dissolve it in 4-5 ml of 1:7 sulphuric acid ( $H_2SO_4$ ) and filter. Add 1ml of 0.2% diphenylcarbazide. Observe any change in color

**INFERENCE** -A pink color indicates presence of lead chromate

**ADULTERANT-** metanil yellow

**METHOD OF DETECTION-** Take one gram turmeric powder in a test tube. Add 5 ml of water. Add a few drops of concentrated HCl. Observe any change in color

**INFERENCE** -Appearance of pink/violet color which disappears on dilution with water shows the presence of unadulterated turmeric. If the color persists, indicates the presence of metanil yellow.

**ADULTERANTS-** Aniline Dyes

**METHOD OF DETECTION-** Take one-gram turmeric powder in a test-tube and add water to make a suspension. Add 1- 2 ml of rectified spirit. Observe the color of the rectified spirit layer

**INFERENCE** -Immediate separation of yellow color in the rectified spirit layer indicates the presence of dyes.

## **7. Tea**

**ADULTERANTS-** Tartrazine

**METHOD OF DETECTION-** Rub a few dry tea leaves between moist fingers or place them on a wet blotting paper.

**INFERENCE** - If the paper or fingers turn yellow, orange, or red, adulteration is likely

## **8. Fruits ( watermelon, pomegranate)**

**ADULTERANTS-** Erythrosine

**METHOD OF DETECTION-** Rub a cotton swab soaked in water on the surface of a cut watermelon piece or crush a few pomegranate seeds and rub the juice on blotting paper.

INTERENCE- Artificial color transfers onto the swab.

ADULTERANTS- Carmoisine

METHOD OF DETECTION- Add 2-3 drops of liquid ammonia to the extracted juice.

INTERENCE- Artificial colors may change to deep pink or violet.

## 9. Green vegetables

ADULTERANTS- malachite green

METHOD OF DETECTION-Take moist blotting paper and spread the greens/vegetables on moist white blotting paper . Look for color on filter paper. Rub the outer green surface of the vegetable with liquid paraffin soaked cotton. Soak green peas in a beaker of water

INFERENCE -Green color impressions on paper indicates the presence of Malachite green Cotton ball shows green color indicates the presence of Malachite green. Water in beaker is green indicates peas are artificially colored

## III Impacts Of Food Colours On Human Health

The relevance of colours in food sector, undoubtedly, cannot be denied. It is colour which makes a food appetizing, attractive and desirable to the consumers. Though, use of certain colours has been banned in foods. Few health hazards include stomach ache, body ache, anaemia, and increase within the incidence of tumors, pathological lesions in very important organs, abnormalities of skin and eyes (Shah *et al.*, 1999). It was reported that *Auramine* inhibit growth and lead to dysfunction of the liver and kidney. *RhodumineB* was shown to cause retardation of growth, haemolysis of red blood cells and degenerative changes in the liver and kidney. It also adversely affected the immune system. *Sudan dyes* were found to be toxic to liver and produced kidney lesions. *Malachite green* caused decreased appetite, growth rate and fertility rate. It also caused damage to organs like liver, kidney, heart and spleen, as well as, lesions of skin, eyes, lungs and bones. *OrangeII* resulted to retardation of growth, increased mortality and haematological changes. *Metanil yellow* consumption

lead to degenerative changes in the stomach, ileum, rectum, kidney, liver, ovary and testis. Metanil yellow is one of the most commonly used water soluble non-permitted dye to colour foodstuffs including pulses 'with a false presumption that it could be washed out in pre-cooking washings of the pulse. In humans, some of these colours have shown to lead acute food poisoning outbreaks. The people developed with these symptoms had eaten *laddoo* coloured with this dye. In another incident, *biryani* was coloured with metanil yellow caused similar symptoms 2 to 4 hours after consumption. In chilli powder lead chromate was added as a colourant caused lead poisoning among Gurkha soldiers with symptoms of stomach ache, nausea, constipation and anaemia. All the above colours can also mutate genes (mutagenic) and most of them have been identified as potential cancer-causing agents. *Tartrazine* is the food colour most frequently associated with allergic reactions. Asthmatic people are especially sensitive to this yellow colour many have reported a worsening of their asthma attack after consuming food containing tartrazine.

**Table 2 : Synthetic food colorants and industrial dyes with their side effects on human consumption**

| Synthetic food colorants | Side Effects                                                                                                                                                    |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Auramine                 | Inhibits growth, dysfunction of the liver and kidney                                                                                                            |
| Rhodamine B              | Growth retardation, hemolysis of RBCs, degenerative changes in the liver and kidney, adversely affects the immune system                                        |
| Sudan dye                | Toxic to the liver and produced kidney lesions                                                                                                                  |
| Malachite green          | Decreased food intake, growth rate and fertility rate, damage to organs like liver, kidney, heart and spleen as well as lesions of skin, eyes, lungs and bones. |
| Orange II                | Growth retardation, increased mortality and haematological changes                                                                                              |

|                |                                                                                                                                 |
|----------------|---------------------------------------------------------------------------------------------------------------------------------|
| Metanil Yellow | Degenerative changes in the stomach, ileum, rectum, liver, kidney, ovary and testes, giddiness, weakness, vomiting and cyanosis |
| Lead Chromate  | Stomach ache, nausea, constipation and anaemia.                                                                                 |
| Tartrazine     | Allergic reactions and worsening of asthma attack in case of asthmatic people                                                   |

## Conclusion

Food adulteration, especially through artificial colorants, is a silent yet dangerous practice that compromises food safety and public health.

To combat adulteration, it is essential to monitor and report the sale of contaminated food products to authorities. Government regulations, strict market surveillance, and consumer vigilance can significantly reduce the prevalence of adulterated food. Educating the public through campaigns, food labeling, and digital awareness initiatives can empower consumers to identify safe, unadulterated products. Always choose natural, unprocessed foods to brighten up meals and educate others about the benefits of clean eating. If artificial food coloring is necessary, purchase products with an ISI certification to ensure quality and safety. Reject artificially colored rice, pulses, sweets, spices, and beverages. Opt for trusted brands, check labels, and perform simple home tests to detect adulterants. By staying informed, raising awareness, and supporting stricter food safety laws, we can collectively fight this menace and protect public health.

## Acknowledgement

I would like to express my sincere gratitude to Swami Vivekananda University for providing the necessary support required to complete this review paper. I extend my heartfelt thanks to my guide, Dr.Moumita Das ma'am for providing her invaluable guidance, encouragement, and insightful feedback throughout this work

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