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Food Colours and their Chemistry

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Abstract—*There is a saying that 'We eat with our eyes first'. Colours play an important role in our life as well as food. Food colours influence our perception of its taste. This paper details about history of food colouring, its need and its chemistry. Natural food colours like chlorophyll, turmeric, saffron, carotenoids etc. have been used for centuries. With time, synthetic food colours like allura red, tartrazine, brilliant blue, quinoline yellow have been derived from chemicals. Now-a-days due to increasing competition, packaged and processed food companies are using food colours to make their product visibly attractive and saleable. It is safe to add permitted colours in prescribed limits to the food .Though we have regulatory bodies like Food Safety and Standards Authority of India (FSSAI) to check and balance the food additives but there are concerns regarding the use of artificial colours. The effects of its usage over a long time, chemical properties, interaction with the food and its purity are the factors that need to be regulated. There are hidden dangers of using these synthetic colours which are commonly used in baked foods, candies, ice creams, etc. Studies show that over usage of these can cause adverse effects on health like allergy, hyper activity and even tumors. As a result people are shifting to organic food colours but this change is still not popular.*

Keywords*: Food colour, natural, synthetic, food safety, chemistry.*

Colours have an important role to play in our life. They affect our mood and emotions. Similarly, colours from our mom's kitchen, make us feel the flavours. Colourful cuisines always attract appreciation. Green colour can be added to *SarsonkaSaag* so that it looksgreener and red can be added to Chilli Potato so that it looks redder.

FOOD COLOURS

Food colour, is any dye, pigment or substance which on addition to the food, gives it colour. Usually, dull coloured foods don't attract the consumers. Adding colours elevates the look of the food and makes it more attractive. It also influences our perception of its taste. Sometimes, the loss of its colour during processing is made up by adding food colours.[1]

HISTORY

- Around 1500 BC, natural extracts from saffron, turmeric, etc. were used by Egyptians to improve the flavour and looks of their food.
- White bread was prepared by mixing flour with alum(whitening agent)
- Wine was artificially coloured.
- Silver, gold or copper were even used to garnish the food in bright colors.
- Aztec people living in valley of Mexico, used to cultivate an insect, known as cochineal from which dye was extracted. These days it is named as Natural Red 4 and used as food colour.
- Plant extracts of various shades like turmeric, indigo, marigold, parsley, spinach, flowers petals also gained significant place in food colouring.
- Since eighteenth and nineteenth century, synthetic food colours are being used in cheese, ice cream, jellies, pastas etc.
- Gradually synthetic coloursalso gained popularity and chemicals like copper sulphate, vermillion and black lead found a place in food colour industry without taking into account their ill-effects.

This way people gave a touch of colour to make an otherwise dull-looking simple foodappear tempting.[2]

TYPES OF FOOD COLOURS

There are two main categories

- Natural food colourings (derived from plants)
- Synthetic food colourings(derived from chemicals)

NATURAL FOOD COLOURS

These are derived from Seeds, Vegetables, Flowers, Fruits and Insects, etc. Popular natural colours which we use today are same as the ones used in olden times. eg: Carotenoids, Anthocyanins, Turmeric, Carmine etc.

Carotenoids[3]

Carotenoids have a deep red, yellow or orange colour. Their structure involves arrangement of eight isoprenoid units whose order is inverted at the molecule center. On the basis of their

constituents, Carotenoids are classified as carotenes (having carbon and hydrogen) and oxycarotenoids(having carbon, hydrogen and oxygen). Lycopene and beta-carotene are part of carotene group. Oxycarotenoids contain yellow pigment.Carotenoids impart bright red, orange, and yellow colors to many fruits, vegetables and flowers. They are being used as food coloursfor centuries. They are one of the most important colour components of saffron, pepper, and red palm oil. Their colour and beneficial properties like vitamin A precursors and antioxidant property, have led to their significant role in the food industry.

Beta Carotene[4]

It is a red-orange pigment found in plants and fruits like carrot from which it derives its name. In Greek "beta" and in Latin "carota" means carrot. It is a carotenoid. Beta carotene is converted into vitamin A, an essential vitamin. Onions, carrots, peas, spinach and squash are examples of food rich in Vitamin A. It is an excellent antioxidant.

Anthocyanins [5]

These are water solublevacuolar pigments present in the plantsand have colour according to the pH of the vacuole:

- Under very acidic conditions - Red
- In intermediate pH conditions - Purple-blue
- In alkaline conditions - Yellow-green

Structurally they are polyphenols and belong to flavonoids group. Plants rich in anthocyaninsare : blueberry, raspberry, black rice, eggplant peel. Anthocyanin extracts are listed as food colour but not listed as colour additive. Their sugar-free molecule is called **anthocyanidins.**

Turmeric [6]

Turmeric (*Curcuma longa)*is a flowering plant which is commonly used as a coloring and flavoring agent in many curries. The underground stem of turmeric is known as rhizome. These are first boiled in water, dried and then ground to give a deep orange yellow powder. It is also used to colour butter, cheese, yoghurt etc. It is many a times, utilized as an economical replacement of saffron.

Carmine[7]

Carmine gives deep red colours. It is derived from the insect cochineal which produces carminic acid. Thedried insects are boiled in water or in an ammonia or sodium carbonate solution. It is then filtered, alum is added and red aluminium salt, called "carmine lake" is produced. Earlier it was mentioned as "natural color" on ingredients lists of food item. But because cochineal can provoke severe allergic reactions in some people, it needs to be mentioned as allergen.

Betanin or Beetroot Red[8]

It is obtained from the extract of beetroot juice.

The color of betanin depends on pH:

pH 4-5 : bright bluish red colour

pH>5 : blue violet colour

pH>7 : yellow brown colour (degradation by hydrolysis)

It is used to give colour to ice cream, sugar confectionery, fruit or cream fillings, meat and sausages.

Saffron [9]

It is the world's costliest spices by weight. Saffron is isolated from the flower of plant *Crocus sativus*.

Annatto [9]

It is isolated from the seeds of the achiote tree. It is carotenoid-based yellow to orange food colouring and flavouring agent.

Chlorophyll Color [9]

The chloroplasts of algae and plants contain a green pigment called chlorophyll. Due to its presence, plants can absorb energy from light. It can be isolated and used as food colour.

SYNTHETIC FOOD COLOURS

They are derived from chemicals and are used in food industry and pharmaceuticals. Their potential sources are petroleum, petrochemicals and mineral compounds. Some examples are:

(a) Indigo Carmine
[5,5′-indigodisulfonic acid sodium salt]
(b) Allura Red AC or Red 40
[Disodium 6-hydroxy-5-[(2-methoxy-5-methyl-4-sulfophenyl)azo]-2-naphthalenesulfonate]
(c) Quinoline Yellow WS
[Sodium 2-(1,3-dioxoindan-2-yl)quinolinedisulfonate]

E NUMBERS [10]

Assessment safety and approval of food additives throughout the European Union are done by the European Food Safety Authority. Chemicals which can be used as food additives within the European Union and Switzerland are given codes as **E numbers**.

FD&C DESIGNATION [11] [12]

The certification is not required for the natural and natural-like food colours. Nine FD&C (Food, Drugs & Cosmetics) certified color additives have been listed by US Food and Drug Administration (FDA) for use in foods in the United States:

1. **FD&C Blue No. 1: Brilliant Blue FCF - colour blue[13]**
   It is a synthetic dye classified as a blue triarylmethane dye. It is produced by the condensation of 2-formylbenzenesulfonic acid and corresponding aniline followed by oxidation. It is usually a disodium salt.
   The chemical formula: $C_{37}H_{34}N_2Na_2O_9S_3$.
   E number: E133
2. **FD&C Blue No. 2: Indigo carmine - colour indigo [14]**
   It is obtained by sulphonation of Indigo so that it becomes water soluble and can be used as food colourant.It also works as a pH indicator. It has blue colour at pH 11.4 and yellow at 13.0.
   The chemical formula:$C_{16}H_8N_2Na_2O_8S_2$
   E number: E132.
3. **FD&C Green No. 3: Fast Green FCF - colour green [15]**
   It is a sea greentriarylmethane food dye.
   The chemical formula:$C_{37}H_{37}N_2O_{10}S_3+$
   E number : E143
4. **FD&C Red No. 3: Erythrosine - colour pink [16]**
   It is a fluorone dye.It gives cherry or melon-pink colour to the food.
   The chemical formula: $C_{20}H_6I_4Na_2O_5$
   E number : E127
5. **FD&C Red No. 40: Allura Red AC - colour red [17]**
   This is a red azo dye present as red sodium salt. It is a popular dye and is used in some tattoo inks and also in many products like cotton candy, soft drinks, children's medications, and even in dairy products.
   The chemical formula:$C_{18}H_{14}N_2Na_2O_8S_2$
   E number : E129
6. **FD&C Yellow No. 5: Tartrazine - colour yellow [18]**
   It is a lemon yellow azo dye. It can also be used with Brilliant Blue FCF or Green S to produce various green shades.
   The chemicalformula:$C_{16}H_9N_4Na_3O_9S_2$
   E number E102
7. **FD&C Yellow No. 6: Sunset Yellow FCF- colour orange [19]**
   This is a petroleum-derived orange azo dye
   The chemicalformula:$C_{16}H_{10}N_2Na_2O_7S_2$
   E Number E110

FSSAI [20]

In India, it is the responsibility of FSSAI to lay down and regulate the rules for manufacture, storage, distribution, sale, import andavailability of safe and wholesome food to all the citizens of the country. FSSAI also provides the information about foodsafety and hygiene.

FSSAI regulations on food colouring:

No colouring matter may be added to food unless permitted by the Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011.

List of colours allowed to be used are:

(a) Natural or Natural-like -

- Carotene & Carotenoids
- Chlorophyll
- Riboflavin (Lactoflavin)
- Caramel
- Annatto
- Saffron
- Turmeric

(b)**Synthetic**

- Red derived from: Ponceau 4R, Carmoisine, and Erythrosine
- Yellow derivedfrom: Tartrazine and Sunset Yellow FCF
- Blue derivedfrom: Indigo Carmine and Brilliant Blue FCF
- Green derivedfrom: Fast Green FCF

FSSAI permits the use of colour as an additive in products like flavoured milk, yogurt, ice-cream, biscuits, , cakes, confectionery, savories, , preserved or processed fruits, jam, jellies, Jelly crystal, Custard powder, carbonated and non-carbonated beverages etc.

It is regulated that Synthetic coloursare allowed upto100 ppm of the final food product for consumption. However, in some foods and beverages, mentioned in regulations, the maximum limit of permitted synthetic food colours may be up to 200 parts per million of the final food product for consumption.

The declaration of the information about the food colours on the label has to be according to the FSS (Packaging & Labelling) Regulations, 2011.

DANGERS OF FOOD COLOURS [21] [22]

Food colours are added to make food stuff decorative and appetizing. These colours modify the flavours and texture of the food items. But now a days, they have entered our lives in a huge way. They mislead the consumers. Most of the synthetic food colours are synthesised in labs using highly toxic substances and are also derived from petroleum. Some of them contain benzene which is a known carcinogen and can lead to occurrence of tumors.As kids are in their developing stage so they are more sensitive to the food colours being used. Studies show a significant correlation between hyperactivity, irritability and agressiveness in children and artificial food colours.These artificial food colours can also induce allergic reactions.

CONCLUSION

Though we have regulatory bodies like Food Safety and Standards Authority of India (FSSAI) to check and balance the food additives but there are concerns regarding the use of artificial colours.Food colours used in food must be in the permitted list given out by FSSAI in India. It should be readily

soluble in water and stable over the pH range of the particular food. It should be non-toxic and should not exceed the permissible limits. Sometimes even the safe food colours are used in excessive amounts to give the food a nice colour, which may be harmful. Consumer awareness in this regard is also important as the alternate names of food colours are mentioned on the food labels.**The disadvantages of using artificial food colouring seem to outweigh the advantages.** To stay away from these food colourings, people these days prefer to cook whole food diet but because of theirbusy schedules they depend on processed food. In these circumstances it is better to go for organic products, use **unprocessed meats, use natural spices** and make **our own food coloring additives from natural products.** Even the food processing industry also needs to be more aware of the health impacts of food colours being added. However, the industry will only move towards limited use of food colours when there will be pressure from the side of the consumers.

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