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ORIGINAL ARTICLE

A Review Article on Usage of Synthetic Food Colours in Foodstuffs and Food Safety

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ABSTRACT
Humans have always used the colour of a food to form judgments about its desirability. The act of eating (and deciding what to eat) is a multi-sensory experience, synthesizing perceptions of sight, taste, smell, and touch. Colour provides visual information about a food's quality condition, and influence the perception of its flavor. From time to time several studies have been conducted so far to evaluate the toxicity of various synthetic food colours. However, there is a striking paucity of reliable data on important issues like evaluation of risks through adulterants, additives and contaminants. Consequently, the protection of diets from these hazards must be considered one of the essential public health functions of any country, which emphasizes the need for total diet studies. The review deals with the frequent uses, regulatory status and hazardous effects of food colours.
Key words: *Colour, Humans, additives, perceptions, sensory experience.*

INTRODUCTION
Colour is added to food to make it attractive. They have been added to food, drugs and cosmetics for centuries. The addition of colourants to foods is thought to have occurred in Egyptian cities, where candy makers around 1500 BC added natural extracts and wine to improve the products appearance (Meggos, 1995). Up to the middle of the 19th century ingredients, such as the spice saffron, from the area local to the production units were added for decorative effect to certain foodstuffs. In 1856, Sir William Henry Perkin discovered the first synthetic organic dyestuff, mauve, and soon a host of new and different colourants become available (Walford, 1980).
The use of synthetic colours started in food industry in late 1800's without any knowledge of their safety. This led to the frequent usage of colours for decorative purposes and unfortunately to disguise low quality foods. Since there was no control over the use of colours in food, inevitably the need for legislation on the approved list of colours, meeting the health concerns eventually came into force in most countries. In spite of regulatory provisions, various non-permitted synthetic food colours are used in foods. The reasons for their popularity are that they are easy to produce, cheaper and superior in colouring properties. The present review is aimed at providing in a nutshell, the status of synthetic food colours, the uses and consequences of their use or harmful effects of synthetic food colours especially in India.
The addition of synthetic colours to food to fulfills one or more of the following reasons:
1. To replace color lost during processing,
2. To enhance color already present,
3. To minimize batch to batch variations and
4. To color otherwise uncolored food.

CLASSIFICATION OF FOOD COLOURS
Food colours are categorized in two major groups *viz.* natural and synthetic.

(A) NATURAL FOOD COLORS:
This category includes food colours obtained from fruits, vegetables, seeds, roots and microorganisms. Some of the commonly used natural colours are chlorophyll, carotenoids, caramel,

cochineal, betanin, riboflavin etc. Natural colours are not stable to heat; light and certain pH levels (Paul, 2003).

(B) SYNTHETIC FOOD COLORS:

These do not occur in nature and have to be manufactured artificially. These are petrochemical products that can be made in practically unlimited quantity and with a high degree of purity, intensive colour concentration and consistent quality. These are resistant to heat, light and chemical influences. Synthetic colours are popular because they are cheap, more intense and more stable than natural counterparts (De Vries, 1997). These colours are found in a wide range of products from sodas, candies, dessert-mixes to commercially prepared baked goods, sausages, hotdogs, toothpastes etc.

Synthetic colours are further divided into non-permitted and permitted.

1. Non-permitted Food Colours:

Use of non-permitted food colours is banned in any food item and in any proportion. Despite of regulations and restrictions by the Prevention of Food Adulteration Act of India, the use of the non-permitted food colours is still prevalent.

2. Permitted Food Colours:

Presently, eight synthetic food colours*viz,* tartrazine, sunset yellow, carmoisine, ponceau 4R, erythrosine, indigo carmine, brilliant blue are permitted to be added to specific food items as recommended by the Prevention of Food Adulteration Act, India (PFAA, 1954). Presently, eight synthetic food colors are permitted to be added to specific food items as recommended by the Prevention of Food Adulteration Act, India (PFAA, 1954) which is as follows.

Table 1: Synthetic food colors recommended by the Prevention of Food Adulteration Act, India

S.No.	Food colour	USA name	EU code
1	Tartrazine	FD&C yellow no.5	E102
2	Sunset yellow	FD&C yellow no.6	E110
3	Carmoisine	FD&C yellow no.	E122
4	Ponceau 4R	FD&C red no.7	E124
5	Erythrosine	FD&C red no. 3	E127
6	Indigo carmine	FD&C blue no. 2	E132
7	Brilliant blue	FD&C yellow no. 1	E133
8	Fast green FCF	FD&C green no. 3	E143

REGULATORY STATUS

The analytical control of food colorants is of considerable importance to the food industry because of their toxic and carcinogenic potential (Combes and Haveland Smith, 1982; FAO, 1984 and Ashkenazi, *et al.,* 1991). Thus, all food colour additives should be carefully checked and regulated by various federal authorities in every country to ensure that the coloured foods are safe to eat and accurately labeled. In India, the use of food colours is regulated under the Prevention of Food Adulteration Act, 1954. According to the 29th rule of PFA Act, the maximum permissible limit of the food colours is 200 ppm of the food. This limit has been amended in 1995 to a level of 100 ppm in the final food or beverages for consumption, except in jams, jellies and canned foods in which a level of 200 ppm is permitted. Under Rule 28 of the PFA Act, the use of synthetic colour is restricted to only specified food items.

SURVEYS CONDUCTED ON CONSUMPTION OF SYNTHETIC FOOD COLOURANTS

Surveys on food colourants are important to check food adulteration and alert the consumers and regulatory agencies to potential food safety issues. Several earlier studies made, have shown the widespread use of synthetic food colourants in various food items. The Food Standard Agency (FSA, 2000) in UK documented the indiscriminate use of colours in Indian foods. Two samples out of 227 had unexpectedly high levels of colours in food items. These were chicken tikka masala containing (2,054 mg/kg) of Sunset yellow and nishan tandoori paste containing (1,668 mg/kg) of Ponceau 4R.

Ashfaq and Masud (2002) conducted surveillance on added food colours in different ready to eat food materials collected from large and small shops of Rawalpindi Cantt. The analysis report revealed that 47.56% of the samples contained non-permitted food colours. The study also revealed that the incidences of the use of non-permitted food colours and colours above permissible limits were higher in the case of the unorganized food makers. A recent survey done by Food Standard Agency (FSA, 2002) revealed that 5 out of 196 samples of packaged sweets contained levels of either Sunset yellow or Carmoisine in excess of permitted limit of 50 mg/kg (Sunset yellow 61-106 mg/kg and Carmoisine 58-70 mg/kg). Rao and Bhat (2003) carried out a study to find the type and level of food colours added in various foods in the city of Hyderabad and rural areas around Hyderabad. The results of the study revealed that a wide variety of colours which do not form part of the Prevention of Food Adulteration Act were added to various food items beyond the statutory limits. Jonnalagadda, *et al.* (2004) investigated the distribution of non-permitted food colours, added to ready to eat foods prepared in the non-industrial sector of Hyderabad, India. This case study revealed that 30.7% Rhodamine, 15.4% Amaranth, 38.5% Fast red colour and 15.4% of Metanil yellow were the widely used non-permitted food dyes. The Mysore GrahakaraParishat (MGP), which has been conducting awareness camps on food adulteration since 1989, collected food samples from 24 shops and discovered that 44 percent of the samples contained banned additives (Nagaraj and Ranganath, 2004). An exposure assessment of synthetic food colours was carried out among 1-5 and 6-18 years old individuals by Rao et al. (2004). The assessment reports revealed that the intakes of some subjects exceeded the acceptable daily intake for colours such as Tartrazine, Sunset yellow and Erythrosine. Guler (2005) analyzed 140 samples of Turkish confectionery and 96 instant drink powders marketed in Turkey. The results revealed that the permitted colourants levels in 63 samples of confectioneries and 35 samples of instant drink powder were higher than the maximum tolerable limit prescribed by the Turkish Regulations.

A household survey was carried out in the urban areas of Hyderabad by Rao et al. (2005) to find out the consumption pattern of various foods during the festivals. The findings suggested that the intake of Tartrazine and Sunset yellow was higher during the festivals due to the excessive use of these colours in sweetmeats, savouries and beverages, which were commonly available during the festivals. A dietary recall on 3141 male and female Kuwaiti and Non-Kuwaiti children from 58 schools was conducted by Husain et al. (2006 a) to assess the intake of artificial colours by 5-14 years old children. The results indicated that out of nine permitted colours, four exceeded their permissible limits namely Tartrazine, Sunset yellow, Carmoisine and Allura red. Further, Husain, *et al.* (2006 b) made a survey to estimate the daily intake of artificial food colours consumed by 5-14 years old children in Kuwait. The results indicated that out of 9 permitted colours, 4 exceeded the limits set by Food and Agricultural Organization (FAO)/World Health Organization (WHO). A survey conducted by Tripathi, *et. al.* (2010) on intake pattern of synthetic colours by different age and socio-economic consumer groups of Lucknow, India. The findings revealed that on average intake of food commodities, only Erythrosine exceeded the acceptable daily intake (ADI) limit in the 1–10 and 11–20 years age groups through sugar toys on both normal (19–115%) and festive occasions (8–236%). However, on maximum likely intake of foods, Sunset Yellow FCF, Tartrazine, Carmoisine and Erythrosine were found to exceed the ADI limits several times, ranging between 14–1, 138% in 1–10 year and 45–765% in 11–20 year age subjects.

TOXICOLOGICAL STUDIES OF SYNTHETIC FOOD

A study was conducted by Nettis, *et al.* (2003) to determine the incidences of intolerance to tartrazine among subjects who experienced an acute episode of urticaria/angiodema following the ingestion of a meal or a product containing tartrazine. The results of the study showed that the percentage of acute urticaria and/or angioedema induced by tartrazine was very low (1%).

The toxicity of FD&C Blue No 1 (Brilliant Blue), which is commonly added to the external nutrition formulations in order to facilitate the detection of gastric aspirate in tracheal secretion of critically ill patients, was carried out by Lucarelli, *et al.* (2004). Two cases of abnormal systemic absorption of FD&C Blue No. 1 were reported in critically ill patients who subsequently died of refractory shock and metabolic acidosis. The haematological changes in rats fed with some synthetic food colouring agents were studied by Aboel-Zahab, *et al.* (1997). The results revealed a significant decrease in the haemoglobin concentration and red blood cell count on rats fed with chocolate colour additives A and B (sunset yellow, tartrazine, carmoisine and brilliant blue in varying concentration). The investigation also demonstrated selective neutropaenia and lymphocytosis with no significant alteration of total white blood cell counts in all groups. Eosinophilia was noted in rats fed on colourantsA only. Serological alterations revealed a significant decrease in serum cholesterol and HDL cholesterol fraction in rats fed with chocolate colourant C (brown HT and indigo carmine), while total protein and globulin fractions were significantly elevated. Significant increase were observed in serum lipid, cholesterol, triglycerides, total protein, globulin and serum transaminases in rats whose diets were supplemented with chocolate colour A and B. No changes were recorded for blood glucose levels. Mekkawy (1998) studied the toxic effects of some natural and synthetic dyes (ponceau, carmoisine, erythrosine, sunset yellow, tartrazine, fast green, indigotine, brilliant blue, chlorophyll, anthocyanin, ß-carotene and caramel) in rats. These dyes caused an increase in serum glutamic oxalic transaminase, serum glutamic pyruvic transaminase, alkaline phosphates, creatinine and total protein concentrations. This increase was more pronounced in animals treated with repeated single higher doses than in those receiving the repeated single lower doses. On the contrary, serum cholinesterase activity was decreased after treatment. Sub-chronic oral toxicity study of orange colour in F344 rats was studied by Miyauchi, *et al.* (1999) for 13 weeks. The results revealed that there was a significant increase in serum cholesterol levels in males given 1.66% or higher concentration of orange colour and in females given 0.05% or higher concentrations, and significant increases in the values of alkaline phosphates in males given 1.66% or higher concentrations, which possibly may be due to the high-fat composition of the colour containing experimental diets. Helal, et *al.* (2000) studied the toxic effects of some natural (turmeric, carmine and chlorophyll) and synthetic (fast green, annatto and sunset yellow) food colourants on young male albino rats was by comparative assessment. The results showed that a significant increases in serum aspartate-amino transferase (AST) and serum urea by the administration of both natural and synthetic food colourants. Except sunset yellow, all colourants, also revealed significant increase in serum total bilirubin. While chlorophyll, fast green and sunset yellow significantly increases serum alanine-amino transferase (ALT). Some of the colourants showed destructive effects on some vital organ functions, which extended even after the recovery period. Helal (2001) investigated progressive effect of the interaction of sodium nitrite and sunset yellow on different physiological parameters in albino rats. The study showed that the ingestion of the mixture of sodium nitrite and sunset yellow significantly decreased the body weight, haemoglobin content and haematocrit percent, RBC and WBC count, serum inorganic phosphorus, serum albumin and serum protein. Whether a significant increases were observed in serum glucose, T3, T4, calcium, GGT, LDH, ALP and cholesterol. The histopathological effects of sunset yellow on the testes of adult male rats were studied by Mathur, *et al.* (2005). The testes showed patchy degeneration of seminiferous tubules. Affected tubules had extensive desquamation and sloughing off almost all the seminiferous epithelium elements lining the basement membrane. Well-developed Sertoli cell, enveloping the vacuoles of varying sizes in tubules, were seen. At places, an apparent increase in the size of interstitium due to the reduced size of the degenerated tubules. Leydig cells were normal in presence. Sperm count diminished as compared to control. Dhatchayani, *et al.* (2002) studied the genotoxic effects of indigo carmine, a commonly used food colourant in the mammalian system. A dose dependent significant increase in all proliferation was recorded in all treatment groups and chromosomal aberrations like-ploidy, gaps and centric fusion were observed in different treatment groups. The mutagenic and genotoxic effects of amaranth and tartrazine utilizing Ames mutagenicity assay and in vivo mouse bone marrow assay were tested by Das and Mukherjee (2004). The results showed that within the restriction of protocol followed, the dyes were found to be non mutagenic and non genotoxic. An investigation to study the cytological effects of the metal complex dye C. I. Acid Violet 78 on *Allium cepa*with respect to the mitotic index and chromosome aberrations was studied by Ningegowda*et al.* (2005). The results revealed that the dye induced a wide range of mitotic abnormalities, which included stickiness of chromosomes, bridges, laggards, fragments, binucleated cells and vacuolated nuclei. Yadav, *et.al.* (2005) evaluated the cytotoxic potential of Erythrosine and Brilliant Blue FCF synthetic food colours on meristematic root tip cells of Allium sativam. At lower concentrations (100 ppm and 250 ppm) erythrosine dye showed stimulatory effect on mitotic index, while at higher concentrations (500 ppm, 750 ppm and 1000 ppm) both dyes showed inhibitory effect on mitotic index. These dyes induced several chromosomal aberrations like: Chromosomal breakage, stickiness, chromatid separation, scattering, extrusion, chromosomal bridge, polarity abolition etc. The study proves that higher concentrations were cytotoxic and mutagenic to the chromosomes of Allium sativum in the form of lethaColour is used in foods and beverages to make them more attractive and to increase consumer's acceptability. The addition of colouring to food is not a modern invention but has been practiced for centuries. Food colors are classified as natural and synthetic food colors. Natural Food Color is derived from variety of sources such as seeds, fruits, vegetables, insect and microorganisms without any chemical treatment. Synthetic food colors are usually water-soluble chemical substances which have been made in factory and can be used in foods without any further processing. These colours are reliable and economical for restoring the original shade of the foods compared to the natural colorants which are expensive and less stable. (Nidasaleem, *et. al.* 2013).l aberrations and these concentrations were also responsible for inhibiting the mitotic activity significantly. The number of aneuploid cells in human lung cells increased in a concentration and time dependent manner after chronic exposure to lead chromate (Holmes, *et al*., 2006).

CONCLUSION

Although many advances in the developments of food colours have been made over the last 25 years, particularly in terms of harmonized legislation and advances in processing and formulation technology, there is still room for future developments. The following conclusions can be drawn to follow up and regulate the use/misuse of Food Colours.

1. Approved food colours are not dangerous to health, so long as their use is limited to approved food items, as well as within the permitted amounts of the food rules.
2. Overuse of approved food colours, is quite prevalent in the consumer market of food and food products.
3. It is highly important to raise this awareness level significantly, using print and other electronic media.
4. The children are exposed more to health risks in this harmful business of food colours.
5. Food laws enforcement agencies at local and provincial levels are not properly qualified, trained and are ill-equipped to deal with the problem of food colours. It demands priority attention of the responsible government departments.
6. There is also a need for the awareness and some basic training to food inspectors, about the use and misuse of food colours and the consequences thereof like the use of textile dyes in the food items.
7. Food Rules which are in force today, have been revised by a Committee of Experts.
8. List of approved food colours and their level of use (100-150 ppm) be clearly defined for execution purposes.

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