



Effect of Dyes on our Health

Aanchal Alok

Research Scholar, Department of Chemistry, Himalayan University (A.P.), India

ABSTRACT: This is in practice from several years that food dyes are added to increase the quality sensitivity of the food. There are two types of dyes: Natural dyes and artificial dyes. The origins of natural dyes are plants and animals. So, the availability of natural dyes is limited and expensive. Artificial dyes are obtained from various petroleum products and have aromatic rings. Dyes are frequently used in eatable items like bakery, confectionery, candies, drinks, rice, processed and cooked foods. Though, dyes are being used in our daily life very much, but we cannot ignore its adverse effects on human body. The toxicity of dyes introduces various disorders in a human body. The dyes have mutagenic property directly as well as indirectly.

KEYWORDS: Synthetic dyes, Natural dyes, dyes use, Toxicity of dyes, Allowable limits.

I. INTRODUCTION

From thousands or hundreds of years dyes are in regular use in human life. Natural as well as synthetic dyes are in human use for many centuries. Generally, every one prefer food which is fresh looking and vibrant. The fade colored food is not welcome by anyone. When dyes are used in food, one question comes out that whether it is safe or not. To overcome this problem, an allowable limit is set by food authorities for every dye which is being used in food whether it is natural or synthetic dye. The black or brown dyes are strictly prohibited in food items because they contain harmful ingredients. The food color was started very first time in Egypt. At that time, natural dyes were extracted from plant sources but as the demand increases rapidly, synthetic dye came into the picture. The synthetic dyes are highly carcinogenic and also increase the quality perceptions. Synthetic dyes also cause many diseases like estrogen enhancers, organ damage and asthma. This is the reason why synthetic dyes are banned in many countries and people are coming back to the use of natural dyes. However, natural dyes are safe in all aspect but they have certain limitations like low yield, costly and also do not produces bright colors and consequently not so vibrant. More research and studies are required in this field to improve the performance and cost effectiveness of natural dyes.

Synthetic Dyes

Synthetic dyes have no nutrition and they are chemically active compounds which give pigmentation or color to cooked food products or processed food, this process is called coloring. The use of food colorants is frequent ignoring its adverse effect on human health. Synthetic dyes give a secondary color to food items or food products. Colors are also called food additives. Use of synthetic colors is very common in our country and also in other countries. Food coloring improves the quality and also gives an appetizing look to the food products and seller can avail full advantage of its good look and make more sales. Food additives are generally coal-tar based components or chemicals. Colors are added in various food items like bakery, soft drinks, sweets, candies and confectionaries. The presentation of food items is improved when dyes are added in the form of powder, semi fluid or pastes.

Purpose of food dye

The use of synthetic dyes is increasing day by day due to various reasons. Few of them are loss of colors of the food items. The color loss occurs mainly due to temperature extremes, storage condition, light and air exposure and moisture. To keep the natural color of the processed food, to increase the color that occurs naturally, to preserve the fat and oils from rancid and for various other reasons synthetic dyes are used. Synthetic dyes keep food items more appetizing and look afresh. Synthetic dyes are also used to restore the original appearance of food whose color is lost in processing. Food items which are colorless in original like ice lollies, sugar and soft drinks can be made more attractive in appearance by adding dyes to them. Food colorants are widely used ignoring its adverse effect on human health. In human population it is observed that adults are less affected by the food colorants than the children.

History of synthetic dyes

Use of dyes in food is popular from a long time. Earlier dyes were used in soft drinks especially in wine. Smoke and



aloe extract were used as a coloring agent in various food items. As a prevalent in food products like cheese, milk, jellies, desserts, confectionaries, jams and butter. In the mid of 18th century the first synthetic dye was prepared by William Perkin. The name of that first synthetic dye was “aniline purple” or “mauve”, from coal tar. After this achievement, many dyes of organic base were produced and consequently they replaced toxic salts.

Types of synthetic dyes

Synthetic dyes are of wide variety and they are used as per requirement in food items. Few of them are given below:

Figure – 1: Artificial food dyes

- i. **Allura red (Red40):** This dye is used to give red color to food products. This is used as a coloring agent in drugs, candies, soda, cosmetics, syrups, beverages and confectionary. This dye is of azo type and is electrically active.
- ii. **Erythrosine (Red 3):** This dye offers cherry-pink color. This belongs to the organ iodide group. This dye is mainly used in candies, oral medication, sausages, baked items and maraschino cherries.
- iii. **RhodamineB:** This dye is used for fluorescent pink color. It is a cationic dye which is basic in nature.
- iv. **Indigo carmine:** This dye is used as a coloring agent in candies, pet food, beverages and other foods.
- v. **Amaranth:** This dye is very much soluble in water. It is also an azo type dye.
- vi. **Lead chromate (Yellow):** This dye is also called chrome yellow. This dye is bright yellowish and it is used in mixing with turmeric powder.
- vii. **Tartrazine (Yellow 5):** This dyes mainly used in various bakery products, beverages, candies, dessert powder, gelatin desserts and many other food commodities. This dye is also used in pharmaceuticals and in cosmetics also. It is very much and very easily soluble in water.
- viii. **Sunset Yellow (Yellow 6):** This is an azo dye used in sausage, drugs, gelatin deserts and confectionary.
- ix. **Food Brown 1:** This dye gives brown colour to the food products. This is basically a mixture of azo dyes which is very miscible in water. This dye is generally used in fish products.
- x. **Green (fast green 3) :** The dyes which are used in drugs, ingested drugs, personal care products, cosmetics product except from eyes, candies, beverages, ice-cream, lipsticks and externally applied cosmetics.

Allowable limits

In view of human health, it is very necessary to keep a limit of the concentration of dye used. An allowable limit of any food additive is set so that it remain safe after consumption up to that extent. The dyes which are used in food products are classified in two categories: permitted and non-permitted food dyes. When a non-permitted dye is mixed with any food product to increase the quantity or to improve its quality or appearance, then this process is called adulteration. Every country has its own laws for this purpose having a common objective to prevent human health from the harmful effect of these dyes. For example, in USA, only seven food colors are allowed while European Union (EU) permits the use of sixteen synthetic dyes. The use of black and brown dyes is strictly prohibited in developed countries because they contain harmful ingredients which give very adverse effect on human health. The maximum allowable limit of permitted colour which can be added to any food product is 0.1 gm per Kg. Food and drug controlling agencies sets allowable limits of synthetic dyes which can be added to any food product. European Food Safety Authority (EFSA) has approved a daily intake of Allura red AC is 7 mg / kg as per body weight of a person.

Natural dyes: In a biological system, a dye which is synthesized, accumulated or extracted from the living cells is known as natural dye.

A comparative study of natural colorants with artificial colorants: Synthetic dyes are commonly referred as food dyes or coal tar dyes are being used from several years in place of natural colorants that are destroyed during the processing of foods. However, the demand of synthetic food colorants is reduced in a great extent due to its harmful effect on human health. Therefore, scientists are doing more research and studies to produce natural colorants because consumers are forcing high pressure on them. Now, the scientists are trying to find out such natural food colorants which are based purely on natural ingredients. There are few disadvantages with the natural colorants like low stability, low color stability, low yield, lower tinctorial and are more expensive than the synthetic colorants.



Remedial properties of natural food colorants: There are many natural food colorants which has medicinal properties. In the treatment of arthritis and cancer, Carotenoids are very much helpful. Anthocyanins are helpful in the cure of coronary heart diseases, hyper tension and liver disorders. Betalains are anti-carcinogenic, anti-viral and anti-microbial. Monascus dyes are anti-mutagenic and anti-tumorigenic.

Advantage of natural food colorants: Turmeric, one of the most widely used natural colorant is used in the bakery, cheese and meat products. Caramels are prepared with different methods and this is used in various food products. Curcumin are obtained from turmeric and legislation of both dependent on the geographical area. Carmine and cochineal are obtained from cochineal which is also called Dactylopius. Fungi also produce monascus pigments. These pigments are produced by solid state fermentation and they are not allowed in United States. However, these colorants are of great importance due to their stability and clarity as compared to other natural colorants.

Limitations of natural dyes: Many advantages of natural dyes are weakened due to certain limitations such as low color, higher production cost and tedious extraction process. In case of few natural dyes, mordant are used to increase the fastness properties of dyes. The use of mordant becomes hazardous in some cases. There are also some problems in the collection of useful plants and their extraction and dyeing process. The use of synthetic dyes also increases the hyperactivity in the children. Therefore, almost all the food product which contains synthetic dyes has a warning notice labeled on the outer surface of their package. That is the reason, use of synthetic dyes are decreasing on daily basis. Many big food product companies are emphasizing their food product mainly on the natural ingredients only. There is a major problem in that process, that the cost becomes almost ten folds if we switch over completely from synthetic to natural dyes.

Use of natural dyes: Natural dyes are also used for histological staining, UV protective clothing, dye sensitized solar cells, pH indicator and functional finishing of textiles.

Dyes characteristics: A dye molecule consists of two types of chemical groups i.e. chromospheres and auxochromes. Auxochrome helps dye molecule in combining with substrate and consequently imparting color. On the other hand, chromosphere is usually an aromatic ring which is related to the coloring property.

Chemistry of natural dyes

Dyes are categorised into different groups based on their chemical structure, colour, uses and their origin.

Natural dyes obtained from minerals

Ocher: Ocher is a natural colorant which is obtained from an impure earthy ore of iron or ferruginous clay. These minerals are generally known as red (hematite) and yellow (limonite). Hematite is a principal ore of iron and also is a constituent of a number of abrasives and pigments. There are various natural colorants which can be obtained from minerals ores for example ocher. Ocher is a yellow or red dye which is obtained from impure earthy ore of iron.

Natural colorants which can be obtained from animals

There are various natural colorants which can be obtained from animals. Few of them are as follows:

Cochineal is a very brilliant red dye which is extracted from an insect called cochineal bug. This cochineal bug generally lies on the cactus plant. This property of cochineal bug was primarily discovered by pre-Columbian of India who dried female cochineal bug ant and then finally grounded it to obtain a fine and rich red powder. When this powder is dissolved in the water, it produces a very brilliant and vibrant deep red colour. In present days, in certain part of the world it is still harvested in order to obtain vibrant red colour. Another example of the deep red colour produced by cochineal bug is the presence of carmine in many cherries and due to this carmine cherry produces red colour. On the basis of their structure this cochineal bug can be categorised as (a) Carotenoids (b) Chlorophyllin (c) Anthocyanins, (d) Betanin. These four categories of plant pigments are most vital and they are mostly used in food colouring. Derivatives of these colorants include Annatto, Caramel, Elderberry, Indigo, Alpha-hydroxynaphthoquinones, Flavones, Anthocyanins, Betacyclin and various other dyes. Annatto is a reddish orange dye which is made from the seed of achiote. Caramel is made from the caramelized sugar. Carmine is a red dye which is derived from the cochineal insect named as Dactylopius. Elderberry is used as a colorant mainly in juice and soft drinks. The Indigo dye is extracted from the plant tinctoria L and this dye is most vital one. Anthraquinone dyes are producing red color and these are obtained from plants and insects. These dyes are having property of good fastness to light because in presence of light complex compounds are formed with metal salts. Alpha-hydroxynaphthoquinones also known as heena is one of the most important members of anthraquinone class of dyes. When we are interested in a yellow colour dye, then flavones are used. Flavones are the commonly and evidently use yellow dyes which are the hydroxy and methoxy derivatives of both flavones and isoflavones. There are also a dye whose chemical structure is



very close to flavones are Dihydropyran. Carotenoids colour is due to the presence of long conjugated double bonds. The main example of this kind are Saffron and annatto. Anthocyanins have properties such as stability, chemoprotective and antioxidant. These dyes are mainly obtained from radishes, purple, sweet potatoes, red potatoes and red cabbage. When we require a red purple pigment then Betacyanin is used to accomplish this purpose. This betacyanin is extracted from *Opuntia stricta* plant. To enhance the drying process glucose syrup was used. This powdered colour shows good stability and strength where it is stored at room temperature for or nearly one month. On the other hand, this colour was very attractive for customers when it was successfully applied into food products, such as yoghurt and soft drinks. Even after a month there is no significant change in its colour.

Dyes which produce blue colour are very rare. In the case of brilliant blue bacteria brought blue back with a punch thanks to an extract from cyanobacteria *Spirulina* is the source of blue colour as this colour is rare among all other available colours produced by the dyes. The demand to use this cyanobacterium to extract blue colour is increasing on a day to day basis. The quality of colour produced by the natural food colorants depends on the raw material used. Fungi can be used to produce colorants in a large amount. However, a deep study and chemotaxonomy tools are required to complete the successful screening using fungal metabolites. In the research of coming years metabolic engineering will definitely be used to create microbial cell factories in order to produce food colour.

Production and analysis of natural colorants

For the production of natural dyes various technologies are used. But the primary requirement and the most important one is the purity. On the basis of required purity it becomes very simple to extract the solvent and supercritical fluid extraction. For the purpose of drying freeze drying or vacuum drying can be used. There are also many technologies available which can enhance the production of colorants in plants. Technologies which are used to analyse natural food contents in various food products are HPLC, chromatography, capillary electrophoresis, and gas chromatography and high performance liquid chromatography. Out of these techniques, capillary electrophoresis is considered best because this technology has several advantages for example very small sample amount, low operating cost, low capillary cost, less time consuming and low wastage.

Synthetic food colour detection

There are different methods which are used for the detection of synthetic food colorants including traditional column chromatography, thin layer liquid chromatography, high performance liquid chromatography, high performance thin layer chromatography as well as reverse phase chromatography, high performance ion chromatography and ion pair chromatography. All these techniques are effective in the detection of synthetic food colorants in various food products.

Food colour certification:

There are nine synthetic dyes which are approved by U.S.FDA. Along with many natural food colouring such as turmeric, carrot, paprika. Red colour is obtained from tomato lycopene extract which is used in strawberry, ice cream and many other red coloured food products. Most of the synthetic dyes which have been used for many decades are obtained from chemical compounds or petroleum. One of the major problems which is faced by the chemist and biotechnologist relevant to the natural food colouring is the production of less attractive colour which are not appealing for which do not give an attractive impression on the customer. No customer will prepare to buy an anaemic or greener strawberry even if it has only natural colorants. On the other hand, he or she will readily buy a vibrant and nice looking strawberry. Another major problem with the natural dye is its high demand and low production which consequently make it very expensive as compared to synthetic dyes. Natural dyes are also not much stable when it is exposed to heat and light. Synthetic dyes require certification before it can be used in the food products. Synthetic colours are of high demand because of the brilliant and uniform colour, variety of colours and also above all of this, the synthetic dyes are much cheaper as compared to the natural dyes. The approved and certified food colours do not add undesirable flavours to food products. Natural colorants do not require any type of certification before use because they are obtained from the natural sources, plants, animal and minerals. Natural colours are more expensive and also add flavours to food products.

Adverse effects of synthetic dyes

When the production of synthetic dyes was started, the raw material was originally obtained from raw petroleum products such as crude oil and coal tar. These days synthetic dyes derived from the petroleum or chemical compounds are used in thousands of food products e.g. candy, oral tablet, soft drinks and serials.



Damage to human organ

Auramine, a dye which produces yellow colour and rhodamine damages and dysfunctions liver, kidney and heavily retards its growth. Rhodamine is also eminent in the breakdown of red blood cells. One of the non permitted food colours in edibles is Lead chromate. When it is used heavily causes neurological disorders, abdominal pain, anaemia, hypertension and lead poisoning. Maternal yellow gives a bad effect on reproductive organs like ovaries and testis. It also affects the liver kidney and stomach of a human body in a bad manner. Not only this, it also makes the skin cell deficient of oxygen which consequently discolour the skin due to inadequate oxygenation of blood causing methaemoglobinaemia in adults within three to four hours after the consumption of food product which is coloured by this dye. Few other dyes like amaranth, tartrazine, erythrosine, allura Red, phloxine and rose Bengal. Amaranth and Tartrazine have been tested clinically and in labs and the reports found that they induce immunosuppressive effects.

Asthma: We know that asthma is the disease which mainly caused by allergy. Allura red and brown dyes cause allergic reactions. Asthma is elevated by Brown dye and Tartrazine because they are known as histamine liberator.

Carcinogens: This dye is found in red 40, Yellow 5 and Yellow 6. Benzidine is present in this dye in the freeform as well as in bounded form. In the food dyes, the bounded form is found in a great concentration. Azo dyes follow three mechanisms to produce such a carcinogenic product. In any product, in the process of metabolism reactive electrophonic intermediate molecules are formed that closely associated covalently with the DNA. Benzidine ring present in azo dyes when is metabolized by the body by anaerobic intestinal microflora produces aromatic amines that causes of intestinal cancer. Acid dyes are widely used in food colouring as well as in textile colouring. Some of them are methyl yellow, methyl orange, methyl red, Ponceau, sunset yellow, tartrazine, acid yellow, and amaranth. This also causes an increase rate of cancer among population living in the industrial area because there are the chances to contact with it in industrialized zone is much more.

These colours are widely used in US in processed macaroni and cheese. In the year of 1990, erythrocin is found as an agent of thyroid cancer. An animal carcinogen azo dye is *p*-dimethylaminoazonbenzene (butter yellow). And two xanthenes dyes, non azo dyes are thought to be mutagenic. Allura red after metabolizing in body produces a product that causes bladder cancer in animals. Some of the other synthetic dyes are also has mutagenic properties. Few of them are lead chromate, rhodamine, auramine, sudan-3, metanil yellow and malachite green. Out of these, Sudan dyes are red, synthetic, fat soluble dyes and they are not allowed to be used as a food colour due to health perilous effects.

Estrogens enhancers

In the human body, it has been found that excessive use of sunset yellow yellow 6 and tartrazine (yellow 5) increases the estrogens. When the level of estrogens is increased in human body whether it is male or female it causes severe problem. In Females, it may contribute to breast cancer and in Mail it may decrease sex drive. Estrogens is found in Red 3 and it has growth stimulating capability, potentially genotoxic and stimulatory for breast cancer.

Hyperactivity disorder

One of the most widely occurring hyperactivity disordering human body. They are of different kind. The most severe activity disorder is Attention Deficit Hyperactivity Disorder (ADHD). This is a quantitative disorder multifactorial and its studies suggest that it is due to some genetic and environmental causes on occurrence in human population. The major symptom of hyperactivity disorder includes low frustration tolerance, lack of attention, hyperactivity and loose temperament. The main causes of ADHD are the much consumption of those food products which contain artificial dyes. Severe hypersensitivity is caused by allura red and Yellow 5 dyes. An experiment over few children below 5 years age was subjected to drinks containing artificial colour with a quantity of 25mg per day and withdrawal after some regular exposes. After that the behaviour of children were observed and it was found that its significant hyperactivity during exposure to the synthetic colour was seen. In an experimental study, it was found that 70% to 90% individuals react to produce a hyperactive behaviour when they were exposed with hundred milligram of synthetic food colour. Tartrazine along with the benzoate produces a very hyperactive implicit effect.

Scenario of food dyes in our country

As we know that our country is a developing nation and it is involved in commercial production of several food items. Manufacturers comprise both the national and international production of food items. Each industrial unit which is involved in the production of food items have their own arrangement of quality check and controls for the maintenance of standards. To reduce or avoid the bad practices which produce low standard food items and consequently due to this lower standard toxication takes place. In our country, the people are not aware seriously about the health issues and this



lack of awareness leads them to a serious situation. No clearly defined premises are set to check the heavy use of harmful components in the food. Some producer in our country follow allowable additives to some extent but the addition of non-permissible colorants in food products by local manufacturer or vendors is reported to be high. In India certain synthetic and natural food colours are permitted to use in food items. According to which some of the permitted food colours is sunset yellow, Brown 4, indigo 10, indanthrene, food blue, green red, food violet and food black. The use of non-permitted synthetic food colorants by private food industries and local products is serious and immediate action is required against it.

Conclusion

As a conclusion, we can say that use of dyes whether it is natural or synthetic both are having adverse effect on the human health. Synthetic dyes are more harmful, more toxic because they are aromatic compounds obtained chemically from petroleum products like coal-tar and mutagens. Natural dyes are unstable, rare and expensive. Presently, there is a serious need to emphasize and prevent the adverse effect of synthetic dyes on human health because the synthetic dyes are involved into high toxication of the human body. This is not only the responsibility of government administration, social awareness program must be started to create awareness at different levels and to the different parts of our society to the harmful aspects of excessive use of non permitted synthetic dyes. In the recent years people has become more conscious about their health and they prefer food based on natural ingredients. Natural dyes are more frequently used in our daily food due to its low pollution, less side effect and non-toxic properties. The research and studies still going on to improve quality as well as quantity of natural dyes but it is not used excessively because of lack of technical knowledge on extraction and dyeing techniques. Major problem with the natural dye in their cost which makes them less useful for every customer because in a developing country like India, every customer cannot afford a high price for regular food items.

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