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Applications of food color and bio-preservatives in the food and its effect on the human health

Subhashish Dey*, Bommu Hema Nagababu

Department of Civil Engineering, Gudlavalleru Engineering College, Andhra Pradesh, India

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ABSTRACT

Color is a key component to increase the ultimate appetizing value and consumer acceptance towards foods and beverages. Synthetic food colors have been increasingly used than natural food colors by food manufacturers to attain certain properties such as low cost, improved appearance, high color intensity, more color stability and uniformity. Varied foods and beverages available in the market may contain some non-permitted synthetic colors and over use of permitted synthetic colors. This may lead to severe health problems such as mutations, cancers, reduced hemoglobin concentrations and allergic reactions. Moreover, 60% of the beverages violated the label requirement without including proper color ingredients. The study concluded that there is a high tendency to use synthetic food colors in confectioneries and beverages and some confectioneries contain unidentified colors including a textile dye. Therefore, the implementation of regulations and awareness programs of food colors for consumers and food manufacturers are highly recommended.

1. Introduction

Food coloring or color additive is any dye or substance that produces color when it is added to food or drink or beverages. Food coloring is used in both commercial food production and domestic cooking purposes. In food technology, food colorants, of several types, are chemical substances that are added to food matrices, to enhance or sustain the sensory characteristics of the food product, which may be affected or lost during processing or storage, and in order to retain the desired color appearance. The visual aspect plays an important role in the selection of food products by modern consumers, color is a key constituent of food and beverages. In recent years, many synthetic food colors have been more used as additives to substitute natural colors, to achieve certain properties, such as improved appearance, high color intensity, more color stability, and color uniformity (Yang et al., 2011; Xing et al., 2012). Compared to natural colors, synthetic food colors have several economically important properties such as low cost, resistance to light and pH and high color stability. Synthetic food colors are chemicals which originate from coal tar derivatives, and most of them contain an azo-group. Varied foods and beverages available in the market may contain some non-permitted synthetic colors as well as the overuse of permitted synthetic colors. Numerous studies have confirmed that the synthetic food colors are a major source of food intoxication and lead to severe health problems. In Table 1 there were several food additives that had been used extensively in the past but are no longer allowed, due to existing evidence of their side effects, toxicity in the medium and long-term, as well as a high frequency of potential health incidents (Tripathi et al., 2007; Williams et al., 1999). The continuously use of permitted synthetic colors is also not safe. The use of non-permitted colors and randomly use of permitted colors are known to provide adverse health effects in the animals and in the humans. The use of food colorants in the production of foods leads to the need for the development of accurate, precise, sensitive, and selective analytical methods for their analysis and quantification (Tanaka et al., 2008).

Biopreservation approaches that have been shown to be promising for the control of microbiological spoilage include lytic bacteriophages, lactic acid bacteria, and bacteriocins. The bacteriophage is a potential candidate for use in chilled fish fillet biopreservation, since it offered effective control of S. putrefaciens under chilled conditions. The Lactobacillus brevis based bioingredient, obtained after growth in a flour-based medium, could represent an innovative strategy in industrial bread production to obtain acidified yeast-leavened products, preventing the ropy spoilage and reducing the negative effects of bran addition (García-Mendieta et al., 2012; He & Chen, 2014). The antimicrobial peptides produced by GRAS microorganisms (bacteria), exhibit a bacteriostatic or bactericidal activity against a wide range of microorganisms, and as such, they have a considerable biopreservation potential. The antimicrobially active metabolites, such as organic acids (lactic and acetic acid), hydrogen peroxide, and antimicrobial peptides (bacteriocins) are major potential for use in the biopreservation, being used as protective

* Corresponding author.
E-mail address: shubhashish.rs.civ13@itbhu.ac.in (S. Dey).

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Table 1
Various techniques and processes for food preservation controls.

S.N.	Techniques	Processes
1.	Reduction in Temperature	Chill storage, Frozen storage
2.		
Reduction in water Activity with added water	Drying, Curing with added salt, nitrate, smoke, conserving	
3.	Reduction in pH	Acidification (E.G. Use of acetic acid, citric acid etc.)
Fermentation		
4.	Removal of oxygen	Vacuum or modified atmosphere packaging
5.	Modified Atmosphere Packaging	Replacement of air with CO_2; O_2; N_2 mixture
6.	Additions of Preservatives	Inorganic (e.g. Sulphite, Nitrite)
Organic (e.g. Propionate, Sorbate, Benzoate, Parabens)		
Bacteriocin (e.g. Nisin)		
Antimycotic (e.g. Natamycin)		
In water –in-oil-emulsion foods		
Techniques that inactivate microorganism		
7.	Heating	Pasteurizations
Sterilization including canning		
Techniques that restrict access of microorganisms to products		
8.	Canning	Canning of foods
9.	A septic processing	A septic packaging

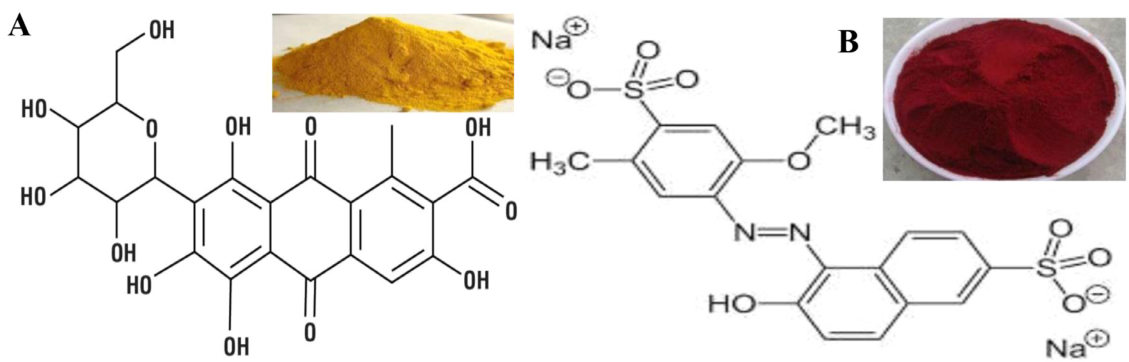

Fig. 1. Food color in (A) Quinoline Yellow and (B) Carmoisine red.

cultures to restrict the growth of undesired organisms (Noli et al., 2019; Sahmoune, 2018). Bio- preservatives are natural sources or formed in food, able to prevent or retard spoilage related with chemical or biological deterioration that prolong product shelf life. According to this approach biopreservation could have been used since ancient times, when fermentation emerged (Moghaddam et al., 2013). The present research work includes a review of natural antimicrobials from a range of sources and their key role in the food preservation.

Food color *available in*

The synthetic food colors are available in following forms:-

- Granular
- Powder
- Lake Colors (Water-insoluble)
- FD &C Colors
- D &C Colors

1.1. Types of synthetic food colors

There are three types of synthetic food colors, they are as follows:

- *Primary Food colors*: Primary food colors as shown in Fig. 1, it is water soluble and exhibit coloring powder when dissolved. Primary food colors have high utilitarian value and vastly used dyes in food, pharmaceutical, cosmetic and various other industries. The main composition of primary food colors are $(CH_2)_2CHNH_2$-COOH, $(CH_2)_2OH$ and $CH_2NHCOCH_3$ etc (Soheila & Sahar, 2011).
- *Quinoline Yellow*: Quinoline yellow, a bright yellow dye with green shade. We provide excellent quality quinoline yellow food colors. These food odors are processed by making use of high grade ingredients and composition of NH-O-Na(SO_3)x, NaO_3S and COONa-N-OH etc.
- *Carmoisine*: Carmoisine, a red to maroon shade in applications, is admired for its usage in add beverages, ice cream, sweat meant and allied. We are offering a wide gamut of carmoisine color and the compositions of $C_2OH_{12}N_2Na_2O_7S_2$ (Sahraei et al., 2013).
- *Tartrazine*: Tartrazine, a synthetic lemon yellow azo-dye, is used as a wide variety of foods including desserts and candies, soft drinks, condiments and breakfast cereals with a great quality, reliability and service. The main composition of tartrazine is $C_{16}H_9N_4Na_3O_9S_2$ (Perera et al., 2015).
- *Erythrosine*: Erythrosine gives a pink to reddish pink shade in applications. It is commonly used in candies, popsicles and cake – decorating gels. Erythrosine food color pigments are widely appreciable in different products with composition $C_2O_H6_{I4}Na_2O_5$.
- *Blended Food colors*: Blended food colors are obtained from mixing different primary and secondary colors either independently or with one another. Blended Food colors is unique in color property and the chemical composition is CH_2OH-NH_2 (Wu et al., 2007).
- *Dark Chocolate Blended* colors: Used for food flavorings, dairy products, bakery items, cosmetics and soft drinks is an essential food coloring ingredients across the world and the chemical composition is $(CH_3)_2$-NO_2-OH and CH_3O-OH etc (Wolbang et al., 2008).
- *Apple Blended* colors: Used for esters, hydrocarbon solvents, paraffin wax, candles and soap kind of coloring. The chemical composition of apple blended color is $(CH_3)_2$=O-OH
- *Coffee Brown Blended* colors: VIPL provides wide range of blended food colors which includes coffee brown and chemical composition is $(CH_3)_3$-N_2-OH

- *Egg Yellow Blended* colors: Used for food, syrups and beverages. They offer a wide range of egg yellow blended colors with chemical composition is $(CH_3)_3$-N-P=O-OH.
- *Lake Food* colors: Lake colors are used where dyes are not suitable due to their solubility in water. Lake colors are bright consistent and useful in industries like pharmaceuticals, cosmetics, links, plastic food containers etc. The chemical composition of lake food is $C_{37}H_{36}AlN_2O_9S_3$.
- *Lake Quinoline Yellow*: Quinoline yellow lake, a food additive is popularly used across various industries and is available at reasonable prices. It is available in powder form and is evenly soluble in variety liquids. The chemical composition of lake Quinoline Yellow is $C_{18}H_{11}NO_2$ (Virtanen et al., 1994).
- *Lake Tartrazine*: Lake tartrazine ($C_{16}H_9N_4Na_3O_9S_2$) is used both in commercial food production and in domestic cooking. It is an active ingredient of various food products like custards, cereals, ice creams, beverages and confectionery items (Suklim et al., 2014).
- *Lake Sunset Yellow FCF*: VIPL has achieved success in manufacturing and supplying lake sunset yellow FCF in market. It is great value in pharmaceuticals, cosmetics, cereals, beverages and other industries. The Sunset Yellow FCF is ($C_{16}H_{10}N_2Na_2O_7S_2$).
- *Lake Erythrosine*: A cherry pink/red synthetic coal tar dye ($C_{20}H_6I_4Na_2O_5$) used as pigments for surface coating, capsules, dry snacks in food packaging material etc (Mohamed et al., 2011; Preston-Martin et al., 1996).

1.2. Artificial dyes currently used in food

The following food dyes are approved for use by both the EFSA and the FDA:

- Red No. 3 (Erythrosine): A cherry-red coloring as shown in Fig. 2(A) commonly used in candy, popsicles and cake-decorating gels.
- Red No. 40 (Allura Red): A dark red dye as shown in Fig. 2(B) that is used in sports drinks, candy, condiments and cereals.
- Yellow No. 5 (Tartrazine): A lemon-yellow dye as shown in Fig. 2(C) that is found in candy, soft drinks, chips, popcorn and cereals.
- Yellow No. 6 (Sunset Yellow): An orange-yellow dye as shown in Fig. 2(D) that is used in candy, sauces, baked goods and preserved fruits.
- Blue No. 1 (Brilliant Blue): A greenish-blue dye as shown in Fig. 2(E) used in ice cream, canned peas, packaged soups, popsicles and icings.
- Blue No. 2 (Indigo Carmine): A royal blue dye shown in Fig. 2(F) found in candy, ice cream, cereal and snacks.

2. Applications of food colors

Following are some of the applications of food colors:-

Bakery: Catering to the needs of bakery manufacture or small bakery and bakers, they provide a color for use in bakery such as biscuits, cookies, cakes and pastries etc. These colors are formulated using the best grade raw materials. These colors possess high quality standard and purity levels. Further, these are offered in various packaging options as per the demands of their clients (Medeiros et al., 2012; Branen et al., 1975).

Beverage: Catering to the needs of beverage industry, people provide beverage colors that are used in the manufacturing of cold drinks, juice, dry mixes etc. Cold drinks look and taste are changing due to adding these colors (Wheeler et al., 1999). Formulated using the highest quality organic substances, these colors are highly effective and safe to use. These colors are provided in proper packing in order to retain their purity and composition for long period of time (Arslan et al., 2008).

Confectionery: Human provide a range of colors to the large manufacturer of confectionery items such as jellies, chewing gum, cream/paste, gums and chews etc. They make sure that these colors are harmless and accurately fresh. These colors are carefully regulated by the experts. Moreover, these are offered in highly appropriate packing options (Demirkol et al., 2012; Sohaib et al., 2016).

Cosmetics & Toiletries: Catering to the needs of cosmetic industry, they provide cosmetic colors that are used in the manufacturing of lipsticks, nail polishes etc. In these colors mainly lake colors are used. These colors are formulated as the best grade raw materials. These colors are customized to meet the specific needs of customers. Some additives have been used for centuries; for example, preserving food by pickling, salting and preserving sweets (Lopez-Larzaro et al., 2008; Sulakvelidze, 2013).

Dairy and Ice cream: Human offer a wide range of dairy and ice cream color that is highly appreciated by the customers. These colors are used in dairy and ice cream manufacturere. These colors are being widely used in milkshakes, processed cheese and water ices etc. These colors make the food items more delightful. These colors are prepared under the hygienic conditions, keeping pH factor into the mind (Virtanen et al., 1994; Mohamed et al., 2011).

Meat & Savories: Human offer colors of meat and savories to food industry. These colors are highly used in fresh comminute meat and seasonings etc. These colors make food colors appetites more. It is very important for food colors to be heat resistance these colors make the foods items more delightful. These colors are food additives and hygienic in use (Lone et al., 2016).

Pharmaceutical: Human offers a wide spectrum of pharmaceutical colors that meet the requirement of clients. These colors are most commonly used as coloring agents in food and pharmaceutical industries as they are highly adaptable and versatile. The pharmaceutical colors are available in different types such as injections, tablets, mouth wash, gels etc. These colors are ideal for coloring products including fats, oils or items lacking sufficient moisture to dissolve dyes. The range of colors should be safe in use (Pandey & Upadhyay, 2012; Woolston et al., 2013).

Seafood: Humans offer a color for use of sea food application. These colors are used in fish coating, smoked fish. It is most commonly used in food agents. These colors are harmless and accurately fresh. Besides, it is subject to several rounds of examinations conducted by the experts. The coloration of a fish is produced by three color pigments which are largely contained within cells called Chromatophores (Gan et al., 2013; Abuladze et al., 2008).

Pet Food: People offer a wide range of pet food color, which are highly appreciated by consumers. These colors are most commonly used by food agent. colors used for pet foods must compile to this same regulations as those used for human foods with the expectations of iron oxides. The range of colors should be provided in appropriate and hygienic packaging as per the specifications of the clients (Tanaka, 2006; Bandara et al., 2012).

This study showed that the predominant consumption of two colors such as tartrazine and sunset yellow mainly from sweetmeats, beverages and fast foods while colors like carmoisine, ponceau 4R and erythrosine were consumed by the intake of confectioneries, jams, jellies showing that the preference of colors is based on the type of foods consumed. The intakes of colors like tartrazine, erythrosine and sunset yellow were high among children due to ingestion of foods containing high concentrations of colors (4.45 and 9 mg). The study emphasized the need to evaluate the risk of the population to colors on a long-term basis (Soheila & Sahar, 2011; Sahraei et al., 2013; Wu et al., 2007).

3. Purpose of food coloring

- Enhancing naturally occurring colors.
- Protecting flavors and vitamins from damage by light.
- Decorative or artistic purposes such as cake icing.
- Masking natural variations in color.
- Offsetting color loss due to light, air, extremes of temperature, moisture and storage conditions.
- Providing identity to foods.
- Providing varieties of wholesome and nutritious food that meets consumer's demand.
- Improves taste.
- Added to food or drink to change its color.

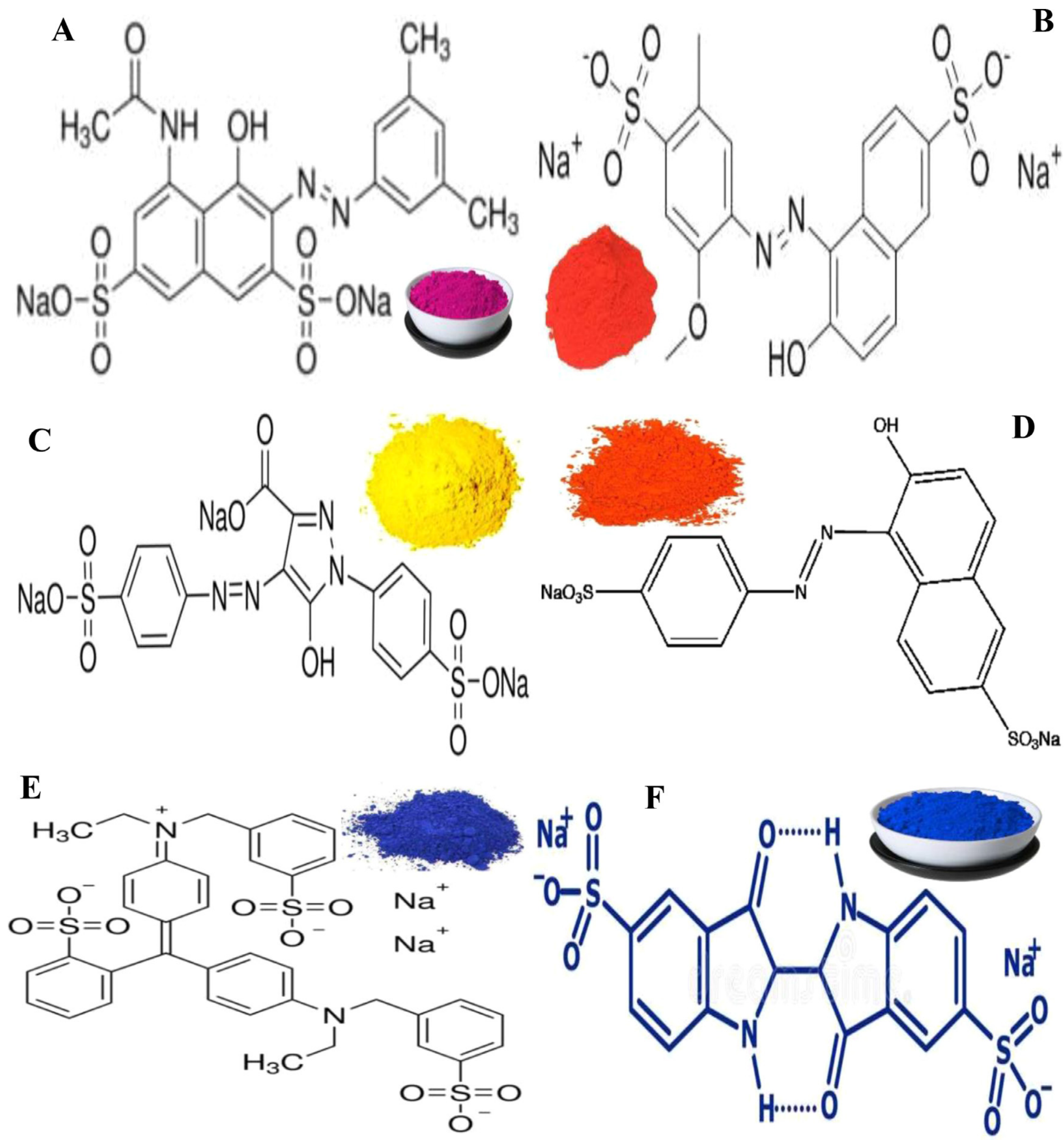

Fig. 2. Artificial Food color in (A) Erythrosine, (B) Allura Red, (C) Tartrazine, (D) Sunset Yellow, (E) Brilliant Blue and (F) Indigo Carmine.

- Improves and maintains nutritional value of food.

4. Effects of food color on the human health

color is a vital constituent of food which imparts distinct appearance to the food product. Artificial coloring becomes a technological necessity as foods tend to lose their natural shade during processing and storage. Most of the food colors tested in the conventional toxicity experiments showed toxic effects at a very high level of intake. Most of the foods borne diseases reported are due to the consumption of non- permitted textile colors (Kroger et al., 2006; Lhotta et al., 1998).

Hyperactivity in Sensitive Children: A small study found that 73% of children with attention deficit hyperactivity disorder (ADHD) showed a decrease in symptoms when artificial food dyes and preservatives were eliminated. Another study found that food dyes, along with sodium benzoate, increased hyperactivity in both 3-year-olds and a group of 8 and 9 year-olds. However, because these study participants received a mixture of ingredients, it is difficult to determine what caused the hyperactivity. Tartrazine, also known as Yellow 5, has been associated with behavioral changes including irritability, restlessness, depression and difficulty with sleeping (Atterbury et al., 2003; Goode et al., 2003). The artificial food dyes do increase hyperactivity in children. Yet it appears that not all children react the same way to the food dyes. Researchers at Southampton University found a genetic component that determines how food dyes affect a child. Studies suggest that there is a small but significant association between artificial food dyes and hyperactivity in children. Some children seem to be more sensitive to the dyes than others (Ghoreishi et al., 2012; Khanavi et al., 2012).

Cancer: While most food dyes did not cause any adverse effects in toxicity studies, there is some concern about possible contaminants in the dyes. Red 40, Yellow 5 and Yellow 6 may contain contaminants that are known cancer-causing substances. Benzedrine, 4-aminobiphenyl and 4-aminoazobenzene are potential carcinogens that have been found in food dyes. These contaminants are allowed in the dyes because they are present in low levels, which are presumed to be safe (Hallagan et al., 1995). With the exception of Red 3, there is currently no conclusive evidence that artificial food dyes cause cancer. More research needs to be done based on the increasing consumption of food dyes. From this research work we learnt that although the synthetic food colors maybe useful for decorating food items, beverages, pharmaceuticals and other purposes, they do cause some problems in the human body. According to Federal Food, 1958 it is better to use the products which are naturally obtained than using the products filled with synthetic food colors even if it is a little authorized amount. Therefore I conclude that synthetic food colors are harmful for human health (Wheeler et al., 1999).

Allergies: In multiple studies, Yellow 5 also known as tartrazine it causes hives and asthma symptoms. Interestingly, people who have an allergy to aspirin seem to be more likely to also be allergic to Yellow 5. In a study conducted in people with chronic hives or swelling, 52% had an allergic reaction to artificial food dyes. Most allergic reactions are not life-threatening. However, if you have symptoms of an allergy, it may be beneficial to remove artificial food dyes from your diet. Red 40, Yellow 5 and Yellow 6 are among the most commonly consumed dyes, and are the three most likely to cause an allergic response. Some artificial food dyes, particularly Blue 1, Red 40, Yellow 5 and Yellow 6, may cause allergic reactions in sensitive individuals (Branen et al., 1975; FDA, 1993; Bigwood et al., 2008).

4.1. Various factors effect on the human health

I. The most concerning claim about artificial food dyes is that they cause cancer.
II. However, the evidence to support this claim is weak. Based on the research currently available, it is unlikely that consuming food dyes will cause cancer.
III. Certain food dyes because allergic reactions in some people, but if you do not have any symptoms of an allergy, there is no reason to eliminate them from your diet.
IV. The claim about food dyes that has the strongest science to back it up is the connection between food dyes and hyperactivity in children.
V. Several studies have found that food dyes increase hyperactivity in children with and without ADHD, although some children seem to be more sensitive than others.
VI. If your child has hyperactive or aggressive behavior, it may be beneficial to remove artificial food dyes from their diet.
VII. The reason dyes are used in foods is to make food look more attractive. There is absolutely no nutritional benefit of food dyes.
VIII. The biggest sources of food dyes are unhealthy processed foods that have other negative effects on health.
IX. Removing processed foods from your diet and focusing on healthy whole foods will improve your overall health and drastically decrease your intake of artificial food dyes in the process.
X. Food dyes are likely not dangerous for most people, but avoiding processed foods that contain dyes can improve your overall health.

A chemical added to a particular food for a certain reason during processing or storage which could affect the characteristic of food or become part of the food. Preservatives are additives that inhibit the growth of bacteria, yeasts and molds in food items. Food preservation involves treating and then handling food to stop or slow down food spoilage, loss of quality, edibility or nutritional-value and thus, allow for longer food storage (Zuber et al., 2008; O'Flynn et al., 2004). Preservation usually involves preventing the growth of bacteria, fungi (such as yeasts), and other micro-organisms (although some methods work by introducing benign bacteria, or fungi to the food. Food antioxidants in the broadest sense are all the substances that have some effect on preventing or retarding oxidative deterioration in foods (Amin et al., 2010).

5. Applications of various preservatives in the food

Preservatives are additives that inhibit the growth of bacteria, yeasts and molds in food items. Some additives have been used for centuries; for example, preserving food by pickling (with vinegar), salting, preserving sweets or using sulfur dioxide as in some wines. Food preservation involves treating and then handling food to stop or slow down food spoilage, loss of quality, edibility or nutritional value and thus, allow for longer food storage (Sharma et al., 2009; Viazis et al., 2011). Preservation usually involves preventing the growth of bacteria, fungi (such as yeasts), and other micro-organisms although some methods work by introducing benign bacteria, or fungi to the food. Preservatives or antimicrobial agents play an important role in today's supply of safe and stable foods. Increasing demand for convenience fast foods and reasonably long shelf-life of processed foods make the use of chemical food preservatives imperative. Some of the commonly used preservatives such as sulfites, nitrate and salts used for centuries in processed meats and wines (Bunin et al., 1994; Huang et al., 2012; Carter et al., 2012).

5.1. Food preservation

5.1.1. Removal of microorganisms

- Usually by filtration
- Commonly used for water, beer, wine, juices, soft drinks and other liquids

5.1.2. Chemical-based preservation

- GRAS
- Chemical agents "generally recognized as safe"
- pH of food affects effectiveness of chemical preservative
- Sodium benzoate
- Sorbic acid
- Sodium or calcium propionate
- Sulfur dioxide

5.1.3. Preservative used in food

- Improves the nutrient value
- Prevents cancer causing agents from forming
- Anti caking agents
- Bleaching agents: dough conditioners
- Coloring agents
- Emulsifiers and stabilizers
- As preservatives and prevents fats from rancidity
- To slow growth of micro-organisms

5.2. Choices of antimicrobial preservatives agents

- The choice of antimicrobial agents based on
- Antimicrobial spectrum of the preservative
- The chemical and physical properties of both food and preservative
- The conditions of storage and handling
- Assurance of a high initial quality of the food to be preserved

5.2.1. Microbiology of fermented foods

Fermentation is an important method of preserving foods. Microbial growth causes chemical and/or textural changes to form products that can be stored for extended periods. Fermentation also creates new, pleasing food flavors and odors. Some foods, such as many cheeses, wines and beers will keep for a long time because their production uses specific micro-organisms that combat spoilage from other organisms. These micro-organisms keep pathogens in check by creating an environment toxic for them and other micro-organisms by producing acid or alcohol. Fermented foods are consumed all over the world and show increasing trends (Am et al., 2007; Jiao et al., 2009).

5.2.2. Controlled used of microorganisms

Number of microbes at any time depends on both inoculums size and growth rate. Food spoilage occurs at high populations-density (at stationary phase) and retarding microbial growth delays spoilage. Controlled (usually cool) temperatures, restricted (usually low) levels of oxygen and/or other methods are used to create specific conditions, which support the desirable organisms that produce food fit for human consumption (Hudson et al., 2013; Ferguson et al., 2013).

5.3. Uses of artificial preservatives in the food

Preservative food additives can be antimicrobial; which inhibit the growth of bacteria or fungi, including mold, or antioxidant; such as oxygen absorbers, which inhibit the oxidation of food constituents. Common antimicrobial preservatives include calcium propionate, sodium nitrate, sodium nitrite, sulfites (sulfur dioxide, sodium bisulfite, potassium hydrogen sulfite, etc.) and disodium EDTA (Magnone et al., 2013; Leverentz et al., 2003). The sealed food is heated to kill or inhibit microbial growth. Acidic food is easier to can neutral food heated to > 100 °C; quality and nutritional value declines. Spoilage of canned food occurs by anaerobic organisms (Clostridium and toxin production); gas generation indicates the problems. Advances in molecular technology have enabled the construction of superior strains of starter cultures for food fermentations (Louis & Botulism, 1991; Boca & Smoley, 1993).

5.3.1. Chemical food preservations

- Many are completely safe (sodium propionate). Some may affect human health
- Nitrites (precursors of carcinogens)
- Ethylene and propylene oxides (mutagens)
- Antibiotics (spread of resistance)
- Radiation
- Ultraviolet (UV) radiation
- Used for surfaces of food-handling equipment
- Does not penetrate foods
- Gamma radiation
- Use to extend shelf life or sterilize meat, sea foods, fruits and vegetables
- Microbial Product-Based Inhibition
- Bacteriocins: Bactericidal proteins active against related species
- Some dissipate proton motive force of susceptible bacteria
- Some form pores in plasma membranes
- Some inhibit protein or RNA synthesis
- Eg. Nisin: Used in low-acid foods to inactivate Clostridium botulinum during canning process

5.3.2. Common preservatives used in food

i. Preservatives
ii. Flavoring Agents
iii. Coloring Agents
iv. Emulsifier, Stabilizers and Thickeners
v. Nutrients
vi. Antioxidant
vii. Harmful effect of food additives
viii. Monitoring the use of food additives
ix. Nitrates (III) and Nitrates (V)
x. Sulphur dioxide and Sulphates (IV)
xi. Benzoic acid and Benzoates
xii. Sorbic acid and Sorbates
xiii. Propionic acid and Propanoates

A. *Sodium Benzoate*: Used in fruit juices, pickles. In soft drinks, it is used to prevent growth of micro-organisms in acidic conditions.
B. *Butylated Hydroxy Toluene*: (BHT) Cereals, chewing gums, potato chips as an antioxidant. It keeps oils from going too decomposed.
C. *Gums*: (Arabic, guar, locust bean) used in beverages, candies, cottage-cheeses, dough, drink-mixes, frozen pudding, ice-creams, salad dressings as stabilizers and thickening agents.
D. *Benzoic Acid*: Benzoic acid occurs naturally in many types of berries, plums, prunes and some other spices. As an additive, it is used as benzoic acid or as Na, K and benzoate. The latter is used more often because benzoic acid is sparsely soluble in water, and sodium benzoate is more soluble. The undissociated form of benzoic acid is the most effective antimicrobial agent. The pKa of 4.2; optimum pH range is from 2.5 to 4.0. Benzoic acid is produced commercially by partial oxidation of toluene with oxygen. The process is catalyzed by cobalt or manganese naphthenates (Leverentz et al., 2004; Carlton et al., 2005). The process uses cheap raw materials, proceeds at high yield and is considered environmentally green. This makes it an effective antimicrobial agent in high-acid foods, fruit drinks, cider, carbonated beverages and pickles. Benzoic acid is also used in salad dressings, soy-sauce and jams. Typical levels of use for benzoic acid as a preservative in food are between 0.05 and 0.1%. A health survey in India on 2010 found 30% of tested dried and pickled food products having too much benzoic acid, which is known to affect the liver and kidney (Tuula, 1994; Hoover & Milich, 1994).
E. *Parabens*: Methyl and propyl parabens can be used in soft drinks. Combinations of several parabens are often used in applications such as fish-products, flavor-extracts and salad dressings. Typical food products which contain parabens for preservation include beer, sauces, desserts, soft drinks, jams, pickles, frozen dairy products, processed vegetables and flavoring syrups. Some fruits, such as blueberries, contain parabens as a naturally occurring preservative (Soni et al., 2010; Guenther & Loessner, 2011).
F. *Sorbic Acid*: The sorbic acid is a straight-chain, trans-trans unsaturated fatty acid, 2,4-hexadienoic acid. As an acid, it has a low solubility in water at room temperature. The salts (sodium or potassium) are more soluble in water. Sorbates are stable in the dry form. They are unstable in aqueous solutions because they decompose through oxidation. The rate of oxidation is increased at low pH, by increased temperature and by exposure to light (Bigot et al., 2011; Soni et al., 2012). Sorbic acid and sorbates are effective against yeasts and molds. Sorbate inhibits yeast growth in a variety of foods including wine, fruit juice, dried fruit, cottage cheese, meat and fish products. Sorbates are the most effective in products at low pH including salad dressings, tomato products, carbonated beverages and a variety of other foods. The effective level of sorbates in foods is in the range of 0.05 to 0.30% (Lopez-Larzaro et al., 2008; Pandey & Upadhyay, 2012).
G. *Formaldehyde Acid*: Formaldehyde acid is normally used to preserve dead bodies and also fish. A gas at room temperature, formaldehyde is colorless and has a characteristic pungent, irritating odor. In humans, the ingestion of formaldehyde has been shown to cause vomiting, abdominal pain, dizziness and in extreme cases, can cause even death. There is a limited evidence of a carcinogenic effect (Chibeu et al., 2013; Oliveira et al., 2014).
H. *Sulfites*: Sulfur dioxide and sulfites have long been used as preservatives. Serving both as antimicrobial substance and as well as antioxidant. Sulfur dioxide is a gas that can be used in compressed form in cylinders. SO_2 can also be used to prepare solutions in ice cold water. It dissolves to form sulfurous acid. Instead of sulfur dioxide solution, a number of sulfites can be applied. When dissolved in water, they all yield active SO_2 (Silva et al., 2014; Figueiredo & Almeida, 2017). The most widely used of these sulfites is potassium metabisulfite. In practice, a value of 50% of active SO_2 is used. SO_2 may increase risk for or exacerbate the sensitivity to respiratory conditions that include asthma, bronchial airway problems and emphysema. Sulfites can produce SO_2 gas that can be inhaled while eating. This can cause a sensitive asthmatic to have a sever bronchospasm or constriction of the lungs (Gan et al., 2013; Tanaka, 2006; Endersen et al., 2013).
I. *Nitrates and Nitrites*: Curing salts, which produce the characteristic color and flavor of products such as bacon and red meat, have been used throughout history. Curing salts have traditionally contained nitrate and nitrite. Currently, nitrite is not considered to be an essential component in curing mixtures. It is sometimes suggested that nitrate may be transformed into nitrite, thus

Table 2
Characteristics of Nisin Bacteriocin in the food systems (Figueiredo & Almeida, 2017).

Characteristic	Bacteriocin	Antibiotic
Stability (Temp and pH)	High	Low
Environmental resilience	Low	High
Molecular Diversity	> 800	~ 150
Cytotoxicity	Low	Low to High
Bioflexibility	High	Low
In Vitro/ex vivo	Easy	Difficult
In vivo mobilization	Possible	Difficult
Prey Specturm	Broad and narrow	Usually Broad

forming a reservoir for the production of nitrite. Both nitrates and nitrites are thought to have antimicrobial action. Nitrate is used in production of Gouda cheese to prevent gas formation by butyric acid-forming bacteria (Modi et al., 2001; Leverentz et al., 2001). According to The London Food Commission (1988), the action of nitrate in meat curing is considered to involve inhibition of toxin formation by Clostridium botulinum, an important factor in establishing safety of cured meat products. Major concern about the use of nitrite was caused by the realization that secondary amines in foods may react to form nitrosamines. The nitrosamines are powerful carcinogens and they may also be mutagenic. It appears that very small amount of nitrosamines can be formed in certain cured meat products. Nitrates may lead to development of some chronic diseases. Kidney function may decline thereby affecting the homeostatic regulation of electrolytes (Whysner et al., 1994).

J. *Bacteriocins–Nisin*: Biopreservation is the application of natural or controlled microbiota or antimicrobials as a way of preserving food and increasing its shelf life. Bio-preservation is a technique of food preservation in which antimicrobial potential of naturally occurring organisms and their metabolites are exploited. It is capable to harmonize and rationale the necessary safety standards with traditional means of preservation and modern demand of the food safety and quality. The bio-preservation techniques of various foods are mainly relying on the quality of biological antimicrobial systems such as lactic acid bacteria (LAB) and/or their bacteriocins, bacteriophages and bacteriophage-encoded enzymes (Whichard et al, 2003; Higgins et al., 2005). They are widely used in food industry to get a typical texture and flavor of the food products. Nisin is an antimicrobial polypeptide produced by some strains of Lactococcus lactis. Nisin-like substances are widely produced by lactic acid bacteria. Nisin is a polypeptide with a molecular weight of 3500, which is present as a dimer of molecular wt. of 7000. These inhibitory substances are known as becteriocins. Nisin-producing organisms also occur naturally in milk (Ye et al., 2010; Kang et al., 2013).

The modified bacterio-phages may also be supportive in bio-preservation, however; their safety issues must be addressed properly before selection as bio-preservative agent. Among all the preservation techniques taken now bio-preservation is more reliable from 'farm to fork' concept. The characteristics of various Bacteriocin in the food system is discussed in Table 2. Nisin can be used as a processing aid against gram-positive organisms. Nisin has also been called an antibiotic, but this term is avoided here because nisin is not used for therapeutic purposes in humans or animals. Because its effectiveness decreases as the bacterial load increases, it contains some unusual sulfur amino acids, lanthionine and B-methyl lanthionine. Nisin is the important member of a large class of bacteriocins produced by bacteria that can kill or inhibit the growth of other bacteria. It can cause a vomiting or diarrhea type illness. Nisin contains no aromatic amino acids and is stable to heat. It has been used effectively in preservation of processed cheese (Preston-Martin et al., 1996; Medeiros et al., 2012).

A. Acids: Straight-chain like carboxylic acids, propionic and sorbic acids are used for their antimicrobial properties. Propionic acid is mainly used for its antifungal properties.
B. Antioxidants: Food antioxidants in the broadest sense are all the substances that have some effect on preventing or retarding oxidative deterioration in foods. They can be classified into a number of groups:-
i. Primary antioxidants
ii. Oxygen scavengers
iii. Chelating agents or sequestrates
iv. Enzymatic antioxidants
v. Natural antioxidants

Terminate free radical chains and function as electron donors. They include phnolic antioxidants, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) tertiary butyl hydroquinone (TBHQ), propylgallate (PG) and natural synthetic tocopherols. Most widely used compounds are Vitamin C, and related substances, ascorbyl palmitate, and erythorbic acid (D-isomer of ascorbic acid). They remove metallic ions, especially copper and iron, that are powerful pro-oxidants. Citric acid is widely used for this purpose. Amino acids and ethylene diamine tetra acetic acid (EDTA) are examples of chelating agents (Kang et al., 2013; Hungaro et al., 2013). Superoxide dismutase can be used to remove highly oxidative compounds from food systems. Present in many spices and herbs. Aromatic plant and perceptive are the most potent antioxidant spices. If antioxidants injected in blood-streams it can lead to instant death as it shuts down the neural transmissions system. Antioxidants and its vapors are corrosive to the eyes, skin and respiratory tract and hydroquinone is also toxic (See et al., 2010; Lhotta et al., 1998).

A. *Emulsifiers*: Sucrose fatty acid esters can be produced by esterification of fatty acids with sucrose, usually in a solvent system. When the level of esterification increases to over five molecules of fatty acid, the emulsifying property is lost. At high levels of esterification, the material can be used as a fat-replacer because it is not absorbed or digested and therefore yields no calories (Sukumaran et al., 2015; Soffer et al., 2016). Ascorbic acid in fruit or flor gets preserved. To aid in food processing such as yeast in bread in cheese. Only certain additives are allowed for use amounts are controlled and must be noted on the label. The maximum amounts used are small. They must serve a purpose as safety tested by the industry. Monitoring the usage of additives is ongoing (Mpountoukas et al., 2010; Magnuson et al., 2007).

A number of food preservatives tend to break down tissues of the body more rapidly than they are built up. They disturb the metabolic processes as shown in Fig. 3; have a tendency to diminish the weight of the body. In Food preservative, sulfurous acid or sodium sulfite in daily quantities of 113 to 762 gram of the latter disturbs metabolism. The human's food supply consists primarily of plants and animals and products derived from them. Microbial activities in foods can be viewed from the perspective of the food as a selective environment, despite the diversity of microorganisms that contaminate the surfaces of the raw materials (Hong et al., 2016; Sukumaran et al., 2016). The selectivity is imposed by the physical-chemical characteristics of the food, the additives it contains, the processing techniques, the packaging material, and the storage conditions. It is necessary to distinguish between the shelf-life of two broad categories of foods, namely those that are shelf-stable and those that are perishable. For this discussion, the shelf-life will be treated as it relates to microbial activity only. Microbiological shelf-stability of many foods is related to storage conditions. Some shelf-stable canned foods may undergo microbiological spoilage if they are exposed to increased temperatures permitting the growth of surviving thermophilic spore forming bacteria, whereas these organisms are inactive at ambient temperatures and indeed tend to die during normal storage. Shelf-stable food is distinguished from perishable food in that an attribute or attributes of the shelf-stable food prevent(s) the growth

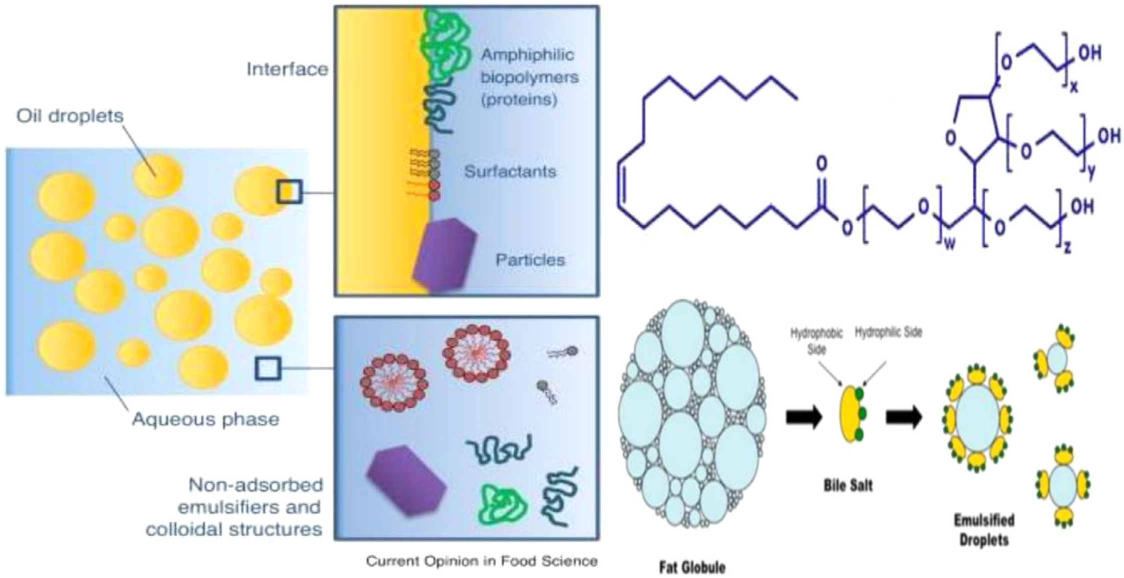

Fig. 3. Uses of various emulsifier agents on the different food systems.

of contaminating microorganisms (Sukumaran et al., 2016; Yeh et al., 2018).

The various processing procedures, additives, packaging methods and storage conditions may be applied to increase shelf-life, microorganisms capable of growth survive and ultimately grow. When such growth proceeds to the extent that undesirable changes are perceptible to the processor, preparer, or consumer, the food is deemed of inferior quality or spoiled and is rejected. The distinguishing feature of perishable foods, in contrast to shelf-stable foods, is that microbiological spoilage is an expected event. It will ultimately occur even if the food has been prepared from wholesome raw materials and has been properly processed, packaged and stored (Kroger et al., 2006; Gustafsson et al., 2003). Microbial activity at the microscopic system level produces effects at the macroscopic and landscape level. The growth of individual microbial cells is autocatalytic; a cell grows to form two cells, each of which can catalyze further growth. When coupled with the relatively fast growth rates of microbes, favorable environmental conditions can produce explosive increases in microbial populations over short period of times. Another application for beneficial microbes used in foods is adding probiotic microorganisms to provide a health benefit to consumers. According to Diagnosis and Statistical Manual of Mental Disorders (1987) the fermented foods are an important part of the food processing industry and of many consumers' diets and are largely produced by lactic acid bacteria that have been selected for their ability to produce desired products or changes in the food (Mai et al., 2015; Snyder et al., 2016; Tomat et al., 2014).

Many advances have been made during the past decade in developing improved bacterial strains for starter culture application, which largely have been made possible through advances in molecular technology. The use of lactic acid bacteria to improve the quality and safety of foods is a rapidly evolving field. With the discovery of new bacteriocins and the development of more efficient approaches to deliver them to foods, the importance of lactic acid bacteria in preserving and providing enhanced safety of food will continue to increase for the foreseeable future (Feng et al., 2011; Vahia, 2013). All food should be safe and free from contamination and spoilage at all points in its journey from its source until it reaches to the consumers. However, food contamination is a serious public health problem. Although the micro flora of raw materials is usually heterogeneous, processing of foods (except those that are sterile) often imposes a characteristic and highly specific microbiological flora. The predominating flora of shelf-stable canned cured meats consists of mesophilic aerobic and anaerobic spore forming bacteria, the predominant organisms resistant to the heat process applied to these products. Food may be contaminated by different microorganisms or by chemicals that can cause health problems for anyone who eats it. Aerobic spore forming bacteria predominate in dry spices and in a number of dry vegetable products. Molds and yeasts predominate in dried fruits (Gao et al., 2011; Ito et al., 1986).

Most food additives are listed on the product label, along with other ingredients, in a descending order by weight. Toxicological tests on animals are used to determine the amount of the additive that is expected to be safe when consumed by humans. This is usually an amount 100 times less than the maximum daily dose at which 'no observable effects' are produced by an additive consumed over the test animal's lifetime (Kotloff et al., 1999; Hammerl et al., 2014). Food manufacturers often prefer artificial food dyes over natural food colorings, such as beta carotene and beet extract, because they produce a more vibrant color. Artificial food dye consumption is on the rise, especially among children. Consuming too much food dye containing contaminants could pose a health risk (Donbak et al., 2002; Hill et al., 2005). The various food additives play a vital role in today's food supply. They allow our growing urban population to have a variety of foods year-round and, they make possible an array of foods without the inconvenience of daily shopping. Food additives perform a variety of useful functions in foods that are often taken for granted. Since most people no longer live on farms, additives help keep food wholesome and appealing while en-route to markets sometimes thousands of miles away from where it is grown or manufactured. Additives also improve the nutritional value of certain foods and can make them more appealing by improving their taste, texture, consistency or color (Hammerl et al., 2014; Kittler et al., 2013; Sorensen et al., 2015). The importance of preserving food is that, it lengthens the shelf life of a food and it slows down the spoilage of food which is caused by microorganisms present in the container or the hands that held it before putting it inside a container. According to Diagnosis and Statistical Manual of Mental Disorders (1987) the importance of food preservation is so that the food cannot be spoilt or can cause illness. Although preservatives are essential to maintain food safety, too much of a good thing is not healthy. Besides allergies, these foods may cause stomach pains, vomiting, breathing problems, hives and skin rashes. The various additives used in the food system according to tolerance level are discussed in Table 3. Some of the worst additives include benzoates, which can cause skin rashes, asthma and perhaps brain damage. Bromates can

Table 3
The various food additives and tolerance level in the food systems [Inetianbor et al., 2015].

Additive	Food Used	Function	Tolerance level
Al ca silicate	Table salt	Anticaking agent	2.0%
BHA	Various foods	Antioxidants	≤ 0.02%
BHT	Various foods	Antioxidants	≤ 0.02%
Caffeine	Cola type beverages	Multipurpose	0.02%
		Anticaking	2.0%
Ca. silicate	Table salt, Baking powder	Fumigants	5.0%
Ethyl-formate	Baking powder	Flavoring agent	0.05%
Gelatin	Puddings fillings	Flavoring agent	0.03%
KMS	General preservative	Antimicrobial	GMP
Sodium bisulphate	Various food	Antimicrobial	GMP
Sodium sulphite	Various food, Wines, fruit juices	Antimicrobial	GMP
SO_2	Dehydrated fruits, Various foods	Sequestrants	0.15%
Stearyl-citrate	Various fat	Antioxidants	0.02%
Thiodipropionic acid	containing foods	Antioxidants	0.05%

cause nausea and diarrhea. Saccharin may lead to toxic reactions that impact the gastrointestinal tract and heart, as well as cause tumors and bladder cancer (Halldorsson et al., 2010; Marti et al., 2013). Control measures directed toward prevention of spoilage have also fallen short of the ideal. For food products designed to be shelf-stable, control is accomplished through processing and/or formulation procedures that result in the inhibition of spoilage organisms. With perishable foods, the object is to achieve the longest possible shelf-life consistent with product safety. The result in products with low microbial loads, since shelf-life and initial level of contamination are directly related in perishable foods. Control of remaining microorganisms is most often achieved by proper refrigerated storage (Moye et al., 2018; Naanwaab et al., 2014). The desirable organoleptic properties of foods such as cheeses, yogurt, buttermilk, sour cream, pickles, and fermented sausages result in part from the activities of a specific microbial flora. Extensive microbiological control procedures are needed to produce "cultured products" of high quality and to ensure that the microbial activities are acted the end products have the desirable sensory properties (Arslan et al., 2008; Demirkol et al., 2012; Bandara et al., 2012).

Before closing concerns whether color should be considered as exerting its psychological influence over flavor perception in more of a ‘bottom-up’ or more of a ‘top-down’ manner. The results support a bottom-up account of at least part of color’s cross modal influence over taste and flavor perception. Of course, the existence of such bottom-up effects should not be taken as evidence to deny the fact that top-down influences are also important. Indeed, color certainly also influence people’s flavor perception in more of a top-down manner as well. Here, it is relevant to note that researchers have demonstrated that labeling, branding, and other descriptive information can all modify the meaning of a given food color and by so doing influence the perceived taste of a food or beverage. Studying the interaction between these influences on flavor perception is an area of growing interest from both a theoretical and more marketing-inspired perspective. Furthermore, the degree of discrepancy between the sensory and hedonic expectations and the subsequent experience appears crucial to the question of whether assimilation or contrast will be observed. Here, recent research has increasingly demonstrated the differing meanings associated with food color in different consumers. Identifying consistent color-flavor mappings and training the consumer to internalize other new associations is one of the important challenges facing the food marketer interested in launching new products, or brand extensions, in a marketplace that is more colorful than ever.

5.4. Applications of bacteriphagses for food processing processes

Bacteriophages are mainly applied in three sectors in the food industry to ensure food safety: primary production, biopreservation and biosanitization. The traditional antimicrobial methods, such as pasteurization, high pressure processing, irradiation, and chemical disinfectants are capable of reducing microbial populations in foods to varying degrees, but they also have considerable drawbacks that deleterious impact on organoleptic qualities. One promising technique that addresses several of these shortcomings is bacteriophage biocontrol, a green and natural method that uses lytic bacteriophages isolated from the environment to specifically target pathogenic bacteria and eliminate them from foods (Goode et al., 2003; Atterbury et al., 2003; Bigwood et al., 2008). The initial conception of using bacteriophages on foods for biocontrol to target a variety of bacterial pathogens in various foods, such as fresh fruits and vegetables and the available products containing bacteriophages approved for use in food safety applications has also been steadily increasing. Phage biocontrol is increasingly accepted as a natural and green technology, effective at specifically targeting bacterial pathogens in various foods, in order to safeguard the food chain (Zuber et al., 2008; O’Flynn et al., 2004). In the context of food safety, bacteriophages address many of the concerns voiced by consumers. Also, phage biocontrol is arguably the most environmentally-friendly antimicrobial intervention available today. The phage preparations require refrigerated storage (typically 2–8 °C), and if used in conjunction with chemical sanitizers, may need to be applied separately, as harsh chemicals can also inactivate the phage particles and render phage biocontrol less effective (Sharma et al., 2009; Viazis et al., 2011; Carter et al., 2012). The biological properties of lytic bacteriophages and other qualities of commercial phage biocontrol products as explained above make phage biocontrol a very attractive modality for further improving the safety of our foods, and an increasing number of companies worldwide are engaging in their development and commercialization (Hudson et al., 2013; Ferguson et al., 2013; Magnone et al., 2013). The high natural specificity, phage preparations can effectively address targeted pathogens in foods. Temperate phages are typically less effective than lytic phages at killing their bacterial hosts. Moreover, temperate phages are capable of integrating their DNA into the bacterial chromosome, and therefore, they can potentially promote the transfer of virulence genes or other undesirable genes (Leverentz et al., 2003; Carlton et al., 2005; Soni et al., 2010).

Listeria monocytogenes is a rod-shaped, Gram-positive, facultative anaerobe. Consumption of foods contaminated with L. monocytogenes causes a range of symptoms in humans such as initial flu-like or gastrointestinal symptoms which, in some cases, progress to encephalitis or cervical symptoms, and possibly stillbirth in pregnant mothers. The non-typhoid serotypes of Salmonella enterica account for many incidents of gastroenteritis worldwide each year. The disease caused by these Gram-negative, rod-shaped bacteria is often self-limiting, with symptoms typically including stomach cramps, fever, nausea and diarrhea. However, life-threatening instances can occur in cases of dehydration and when the bacteria invade beyond the gastrointestinal tract (Guenther & Loessner, 2011; Bigot et al., 2011; Chibeu et al., 2013). Many strains of the

Gram-negative, rod-shaped bacteria Escherichia coli are naturally found in the human gut and are beneficial for our health and wellbeing; for example, they aid in the digestion of food and maintenance of a robust immune system. However, some E. coli strains can and do cause illnesses in humans. In globally more than one million cases of foodborne illness and over one hundred deaths could be attributed to Shiga toxin-producing E. coli, including the O157:H7 serotype. Species of the Gram-negative, rod-shaped bacterial genus Shigella cause a self-limiting gastrointestinal infection with symptoms including hemorrhagic diarrhea and stomach pain (Oliveira et al., 2014; Silva et al., 2014; Figueiredo & Almeida, 2017). Shigella-specific bacteriophage cocktail was used to compare the safety and efficacy of phage administration to antibiotic treatment in mice challenged with a Shigella sonnei strain. Campylobacter spp., Gram-negative, curved rod-shaped bacteria, is major foodborne pathogens of humans, causing gastrointestinal symptoms that can include stomach pain, fever and diarrhea. The intestinal microflora of many fowl and other livestock animals include species of Campylobacter. Additionally, though the route of entry is not fully understood, Campylobacter can frequently be isolated from both the surface of and internally within chicken livers. Zoonotic infections commonly occur in humans when contaminated animal products, such as meats, are handled or consumed (Endersen et al., 2013; Modi et al., 2001; Leverentz et al., 2001).

In the last approximately 12 years, the number of regulatory approvals issued for bacteriophage preparations and their use for improving food safety has been steadily increasing. Bacteriophage must come into contact with susceptible bacterial cells to lyse them. The nature of phage replication cycle (which starts with one phage infecting one bacterial cell and resulting in 100–200 progeny phages bursting from that cell at the end of each replication cycle. Finally, another application-related (and efficacy-affecting) technical challenge is the possible emergence of phage-resistant bacterial isolates. Phages utilize a variety of bacterial structures to initiate the invasion of bacterial cells, including surface polysaccharides and proteins, as well as the flagella (Whichard et al., 2003; Higgins et al., 2005; Ye et al., 2010). Commercial bacteriophage products are currently available and have been approved for use in a growing number of countries. These products can be used to address contamination by specific bacterial pathogens at a variety of time points during food production, including spraying on produce, applying to livestock animals before processing, rinsing of food contact surfaces in processing facilities, and treatment of post-harvest food products, including RTE foods (Kang et al., 2013; Hungaro et al., 2013; Sukumaran et al., 2015). Bacteriophage biocontrol can serve as an additional tool in a multi-hurdle approach to prevent foodborne pathogens from reaching consumers, and this method is especially promising under circumstances when food processors strive to preserve the natural, and often beneficial, microbial population of foods and to only remove the bacteria that may cause illness in humans (Soffer et al., 2016; Hong et al., 2016).

6. Regulations of food and preservatives

There are several regulating agencies that determine what must be added to food and food supplements and the quantities that they must be added so they will not have deleterious effects on the consumers. These substances are termed as generally recognized as safe (GRAS). Each country of the world has its own regulations though there might be similarities among them. In India, for instance, before anything can be added to food, it must be approved by the National Food and Drug Administration and Control (NFDAC) in conjunction with the Standard Organization on India (Sukumaran et al., 2016; Modi et al., 2001; Soni et al., 2012). These regulations are; Label declaration for substances used as food additives, Labeling of synthetic color and mixture of colors in food, food additives not to be described falsely, food additives to bear certain information, processing aids and carry-over of food additives, prohibition against sale of food containing non-permitted food additive, conditions for a request to add to or change food additive, restriction on sale, of baby foods containing food additive, conditions for allowing more than one preservative and ionizing radiation (Inetianbor et al., 2015; Chappell et al., 2020). According to current U.S Federal law and regulations, any substance that is Generally Recognized As Safe (GRAS) for a particular use may be used in food for that purpose without pre-market approval from FDA. General recognition of safety must reflect the views of experts qualified by scientific training and experience to evaluate the safety of substances directly or indirectly added to food. The directive provides a list of vitamins and minerals that can be used in the manufacture of food supplements (Atterbury et al., 2003; Lone et al., 2016; Inetianbor et al., 2015). This could be easily rectified by reducing the wide use of non-essential food additives, which in turn would simply restrict the amount of non-nutritious foods presently on sale, resulting in a wider uptake of more nutritionally dense foods. The main excuse of the food manufacturers and the government officials for the importance of the use of preservatives is that without them foods would soon spoil (Demirhan et al., 2021; Asadnejad et al., 2018).

7. Future prospects of food colors on the human health

This research investigates the role that food color plays in conferring identity and liking to those foods and beverages that assume many flavor varieties. The taste test experiments manipulating food color and label information. Results from this study indicate that food color affects the consumer's ability to correctly identify flavor, to form distinct flavor profiles and preferences, and dominates other flavor information sources, including labeling and taste. Strategic alternatives for the effective deployment of food color for promotional purposes at the point of purchase are recommended. Exposure to the marketing of unhealthy foods and beverages is a widely acknowledged risk factor for the development of childhood obesity and non-communicable diseases. Food marketing involves the use of numerous persuasive techniques to influence children's food attitudes, preferences and consumption. The purpose of food desert research is to understand factors that contribute to food deserts and ultimately to identify ways that facilitate change for health and non-health benefits. This is an emerging field that brings together a variety of disciplines, including public health, nutrition, economics, geography, and urban planning. The final research summarized how additional research is essential for clarifying the causal link between the food environment and health and for informing researchers when they develop the most promising interventions. The study of food deserts and determining their impact on public health is extremely complex and requires multidisciplinary research approaches. Food colors can have the Genetic differences, such as in a person's taster status, can also modulate the psychological impact of food color on flavor perception. By gaining a better understanding of the sensory and hedonic expectations elicited by food color in different groups of individuals, researchers are coming to understand more about why it is that what we see modulates the multisensory perception of flavor, as well as our appetitive and avoidance-related food behaviors.

7. Conclusions

Synthetic food colorants were largely used, but have been progressively substituted by those obtained from natural origins. Numerous side effects and toxicity, at both medium and long-terms, allergic reactions, behavioral and neurocognitive effects have been related with their use. Otherwise, naturally-derived food colorants seem to provide high quality, efficiency and organoleptic properties, and also play a contributive role as health promoters. Anthocyanins, carotenoids, phenolic compounds, beet derivatives, annatto and some curcuminoids are among the most commonly used, while strict regulatory practices have been applied looking for food quality assurance. Food additives have been used for many years to preserve, flavor and color foods, and have played an important and essential role in reducing serious nutritional deficiencies. Food additives help to assure the availability of wholesome, appetizing and affordable foods that meet consumer's demands from season to season while also helping to preserve food from spoilage from microorganism. Synthetic food additives react with the cellular component of the body leading to the various food disturbances (effects). To minimize the risk of developing health problems due to food additives and preservatives, one should avoid the foods containing these additives and preservatives. The food additives must be added in regulated quantities, concentration and should be within the acceptable daily intakes. When considering future developments consideration needs to be given to the demands imposed on the industry by any changes to the regulations with respect to safety issues. Time pressures and ingredient rationalization often mean that the most suitable color is not used, which can cause problems in the future, both in manufacturing, lack of consumer appeal and potential new product failure. color suppliers will continue to mirror the flavor industry by offering bespoke formulations and pre blends along with a comprehensive technical advice. Various studies have shown that synthetic food colorants have considerable toxicological effects. However, the natural food colorants have been found to be relatively safe to humans. This review mainly evaluated scientific researchers from various published journal articles and reports, with a view of clarifying the health implications of using these food dyes [Crowley (2017); (Arnold, Lofthouse, & Hurt, 2012; Crowley, 2017).

Data availability statement

The statements in the paper are properly cited in the manuscript and no additional data's are available.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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