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"Natural Food Color V/S Synthetic Food Color"

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1. *Abstract*

Colouring foods and drinks can increase the aesthetic appeal, consumer acceptance and financial viability of food products. Colour has been added since antiquity to food products, using natural sources of colour such as fruits, vegetables and spices as food colour additives, as natural food colours have been in use for a long time, prior to regulatory oversight. Today, colours – also known as colour additives - are not only required for ornamental qualities in food products but are also required for visual appearance enhancement, for the restoration of colour loss associated with food processing, and to affect consumer choices. Colours and colour additives can be divided into two general categories, natural and synthetic.

Natural food colour includes biological sources like Plants (carotenoids, anthocyanins and chlorophyll), Animals (carmine and cochineal insect), and Micro-organisms (biological and fungal pigments). Pigments are complex organic constituents that potentially hold non-food health benefits such as showcasing antimicrobial, anti-inflammatory and antioxidant properties

INTRODUCTION

I. Background One introductory sensitive specific that affects how consumers perceive food quality and make opinions is colour. Humans have understood the significance of colour in food since the morning of time, linking pictorial tinges to nutritive value, newness, and flavor. Since ancient times, natural colours like annatto, beetroot, saffron, and turmeric have been used in food medication. But as food products became more industrialized, the need for dependable, vibrant, and affordable colourings led to the preface of synthetic food colours.

II. The Meaning and Function of Food Colours Food colours are chemicals that are added to food to ameliorate the natural colour of food products or to add colour that has been lost during processing. They've several uses, perfecting Appearance Foods with appealing colours that are more charming to consumers. Masking Colour Loss Natural colour is constantly weakened by processing, challenging.

III. Food Colour groups Natural Food Colours Drawn from microorganisms, shops, and creatures among other natural sources. Among these are carotenoids, anthocyanins, chlorophyll, and betalains. Strong colouring power and stability define chemically synthetic food colours including xanthene colourings and azo colourings.

IV. Revaluation of the Research Along with evidence of negative goods connected to synthetic colourings, consumers' growing mindfulness of health issues has driven the food sector to look for safer and further environmentally friendly colouring results. Natural colours have certain downsides, too, including lower stability.

1 Review of Literature

I. Review of Literature Food colouring's development is a reflection of both the advancement of food technology and the values of society regarding health, safety, and appearance. In history, only naturally occurring substances could be used as food colouring. Ancient societies enhanced the visual appeal and emblematic significance of food by using colourings deduced from shops and insects. According to reports, Native Americans used annatto seeds and cochineal insects, while the Egyptians used saffron and turmeric(Downham & Collins, 2000). Synthetic colourings were introduced during the 19th- century artificial revolution, allowing for mass product and a wider variety of colours, but they also raised questions about long- term health goods and safety.

II. Natural Food Colourings Natural colours are bioactive composites deduced from factory life, microorganisms, and some creatures. crucial agencies of natural colourants encompass carotenoids, anthocyanins, betalains, chlorophylls, curcuminoids, and carmine. Carotenoids(e.G., β- carotene, lycopene) are lipid-answerable and conduct unheroic to pink colours. They're ample in carrots, tomatoes, and papayas, and have been astronomically studied for his or her antioxidant exertion and part in mortal fitness(Delgado- Vargas et al., 2000; Patel, 2015). Anthocyanins are water-answerable colours observed in berries, grapes, and pink cabbage, chargeable for grandiloquent to blue tones depending on pH. Betalains, generally determined in beets and chard, offer a fully unique magenta diapason and are regarded for his or her antioxidant and anti-inflammatory places(Gengatharan et al., 2015). Chlorophylls give green colour and are pivotal to plant photosynthesis, indeed as curcuminoids from turmeric are valued for his or her bioactivity and colouration. Carmine, a red colour deduced from cochineal bugs, remains debatable due to non temporal, ethical, and allergenic enterprises.

III. Synthetic Food Colourings Synthetic colourings, generally deduced from petroleum or coal navigator, came notorious in the 19th and twentieth centuries for his or her various colours, thickness, and low figure. They're considerably categorised into azo colourings(e.G., tartrazine, evening unheroic), xanthene colourings(e.G., erythrosine), and triphenylmethane colourings(e.G., exceptional blue)(Patel, 2015). These composites are not naturally discovered in reflections still are significantly employed in potables, confectionery, ignited goods, and snacks. Despite their tremendous software, safety worries had been raised over the times. Certain azo colourings had been associated with antipathetic responses, hyperactivity in kiddies(specially the" Southampton Six"), and metabolic conversion into carcinogenic amines in creatures(EFSA, 2013; US FDA, 2020). Regulatory bodies including the FDA and EFSA have reconsidered multitudinous artificial colourings to estimate suitable every day consumption(ADI) stages and reveal lengthy- term exposure.

IV. Technological inventions in Natural Colour product Advances in food technology have further increased the stability of natural colours. styles similar to microencapsulation, spray drying, and nanoencapsulation guard vulnerable colours from being destroyed by the terrain, enhancing shelf life and colour stability(Sáenz et al., 2009). Green birth styles including supercritical fluid birth and ultrasound- supported birth are indispensable sustainable means to gain colours without using poisonous detergents(Chaturvedi & Kumar, 2021). In addition, biotechnological styles similar to microbial turmoil have been promising in yielding high- content, stable natural colours. Monascus, Penicillium, and Rhodotorula strains have been delved for the conflation of anthraquinones, polyketides, and carotenoids, independently(Chaturvedi & Kumar, 2021). Similar developments give scalable and green results to address adding artificial demand for natural colourings.

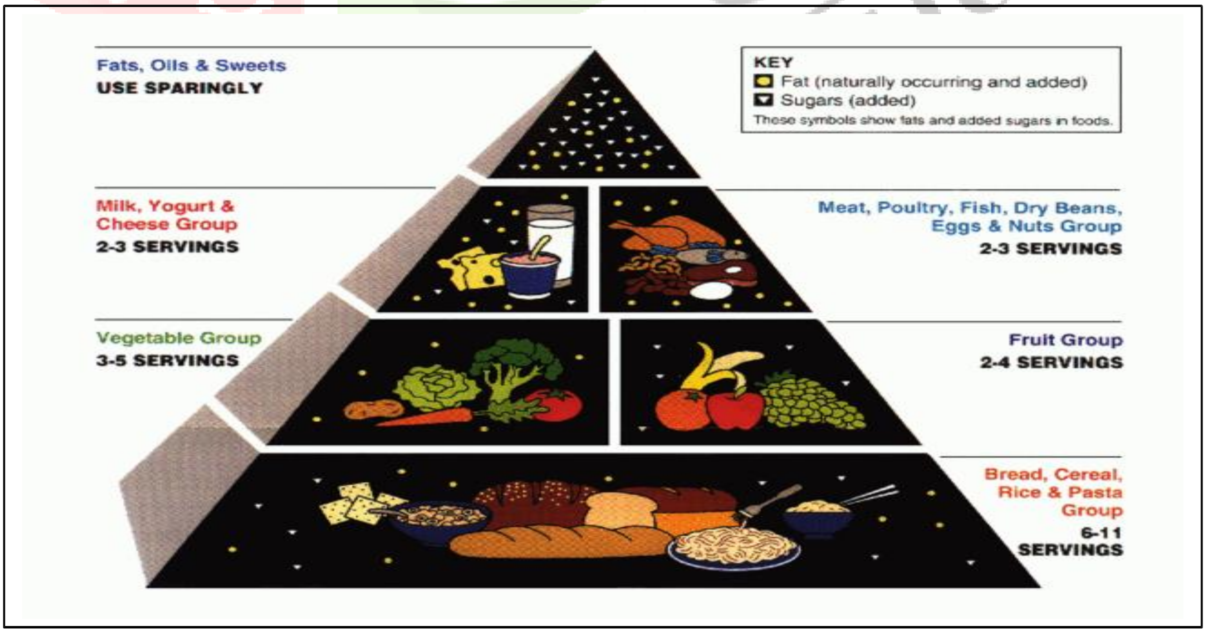
2 METHODOLOGY

Selection of Colourings The study will concentrate on three natural and three synthetic colourings generally used in the assiduity. Type Colour Source Colour Natural Anthocyanin Blueberry/ Red cabbage Blue- red Natural Curcumin Turmeric Yellow Natural Betanin Beetroot Red Synthetic Tartrazine Synthetic(petroleum) unheroic Synthetic Allura Red Synthetic(petroleum) Red Synthetic Brilliant Blue Synthetic(petroleum).

Selection of Colourants

The study will focus on three natural and three synthetic colourants commonly used in the industry.

Type	**Colorant**	**Source**	**Colour**
Natural	**Anthocyanin**	**Blueberry/Red cabbage**	**Blue-red**
Natural	**Curcumin**	**Turmeric**	**Yellow**
Natural	**Betanin**	**Beetroot**	**Red**
Synthetic	**Tartrazine**	**Synthetic (petroleum)**	**Yellow**
Synthetic	**Allura Red**	**Synthetic (petroleum)**	**Red**
Synthetic	**Brilliant Blue**	**Synthetic (petroleum)**	**Blue**



2.1 Stability Testing

- **Conditions: Samples will be exposed to:**
- **Temperature: 25°C (ambient), 60°C (cooking), 90°C (pasteurization)**
- **pH: 3 (acidic), 5 (mild), 7 (neutral)**
- **UV and visible light exposure (8 hours per day for seven days)**
- **Analysis Method: To track pigment deterioration, High-Performance Liquid Chromatography (HPLC) and UV-visible spectrophotometry will be employed.**

2.2 Review of Toxicological Assessment Literature

- **Examination of current toxicological reports and FDA and EFSA ADI limits. mortal intestinal cell lines are used in cell viability assays(e.g., MTT or Alamar Blue) to estimate cytotoxicity at different attention.**

2.3 Study of Consumer Perception

- **Triangle tests are used in sensitive analysis to identify variations between samples with natural and artificial colours.Hedonic tests to estimate preference, taste, and appearance on a 9- point scale.**
- **Survey100 actors were surveyed both in- person and online with an emphasis on.**

2.4 Knowledge of food colouring

- **Geste that involves reading markers**
- **Preference for natural tinges over artificial bones**
- **Amenability to spend further on natural products,**
- **Anticipated issues**

3 EXPECTED OUTCOMES

- Consumer perceptivity into the adequacy and demand for naturally coloured foods.
- A relative frame to guide food manufacturers in colour selection.
- Scientific and policy recommendations supporting the shift toward natural colourings.

Timeline

Month	Activities
1–2	design planning, literature review
3–4	Procurement of accoutrements , methodology finalization
5–7	Stability trials
8–9	toxin assessment and sensitive evaluation
10	Data analysis
11	Report jotting and review
12	Final submission and defense

4 ***CLASSIFICATION*** *AND TYPES OF NATURAL AND SYNTHETIC FOOD COLOURS*

4.1 BRACKET AND TYPES OF NATURAL AND SYNTHETIC FOOD COLOURS

Food colours are vital to the food assiduity because they enhance visual appeal, replenish colour lost during processing, and influence consumer preference. They can be roughly categorised into two groups according to their product and origin locales. Food colouring comes in two kinds: synthetic and natural. Each variety has distinct chemical characteristics, benefits, limitations, and uses.

- ➢ Natural Food Colours
- creatures, shops, and microorganisms are the natural sources of natural food colouring. These colours, which are generally complex organic composites, may have antioxidant and anti-inflammatory parcels.

- ➢ Main Types of Natural Food Colours
- Fat-answerable conjugated double bonds are frequently used as precursors to vitamin A and as antioxidants.
- Variety of Colours unheroic, orange, and red.
- Sources: carrots(β- carotene), tomatoes(lycopene), marigolds, and paprika.

4.2 Sources and Pigments Summary

Source	**Pigment Type**	**Colour Range**	**Example Foods**
Plants	Carotenoids	Yellow–Orange–Red	Carrots, tomatoes
	Anthocyanins	Red–Blue–Purple	Berries, grapes
	Betalains	Red–Yellow	Beetroot
	Chlorophylls	Green	Spinach, kale
	Curcuminoids	Yellow	Turmeric
Animals	Carmine	Red	Candies, yogurts
Microorganisms	Various	Red, brown	Fermented foods

4.3 Synthetic Food Colours

- ○ marketable food products constantly use chemically produced synthetic food colouring. Compared to natural colours, they're more affordable, stable, and pictorial. Some, however, are linked to health issues.

4.4 Important orders of Azo colourings and Synthetic Colours

- ○ Structure azo(- N = N-) groups are present.
- ○ examples include Allura Red(E129), Sunset Yellow(E110), and tartrazine(unheroic No. 5).
- ○ operations frequently set up in snacks, drinks, and sweetmeats.
- ○ enterprises Some have been connected to disinclinations and behavioural issues in kiddies.

4.5 Exemplifications of triphenylmethane colourings

- Fast herbage and Brilliant Blue(E133).
- Uses potables, sweetmeats, and dairy products.
- Features Good light and heat stability, vibrant colours.
- Erythrosine(E127) is an illustration of a xanthene colour.
- Colours range from red to pink.
- Limitation Less stable in light.
- Quinoline Yellow is an illustration of an anthraquinone colour.
- parcels Good stability in light and heat.

4.6 Common Synthetic Dyes

Name	Common Name	Colour	Code	Use Areas
Tartrazine	Yellow No. 5	Yellow	E102	Snacks, beverages
Sunset Yellow	Yellow No. 6	Orange	E110	Soft drinks, desserts
Allura Red	Red No. 40	Red	E129	Candies, sauces
Brilliant Blue	Blue No. 1	Blue	E133	Dairy, jellies
Erythrosine	Red No. 3	Pink–Red	E127	Cherries, sweets

4.7 Natural vs Synthetic Colours: Summary

Feature	Natural Colours	Synthetic Colours
Source	Plants, animals, microbes	Lab-synthesized chemicals
Colour Range	Limited	Wide and vibrant
Stability	Less stable (light, heat, pH)	Highly stable
Health Impact	Generally safe, some beneficial	Concerns with allergies, toxicity
Cost	High	Low
Regulation	Permitted with limits	Strictly regulated
Bioactivity	Yes (e.g., antioxidants)	No health function

4.8 Arising Trends in Food Colour Development

- Microbial colours
- Produced from bacteria, fungi, or algae; offer renewable and sustainable options. E.g., Monascus colours, algal carotenoids.
- Synthetic Biology
- Using genetically finagled microbes to produce natural colours with bettered yield and stability, offering a promising unborn volition.

5 SOURCES AND EXTRACTION OF NATURAL FOOD COLOURS

5.1 Natural Food Colours sources and birth

- Due to consumer demand for clean- marker products and health enterprises about synthetic complements, natural food colouring is getting more and more popular. The primary sources of these colours are shops, microorganisms, and, to a lower degree, creatures. Comprehending their origin, chemical makeup, and applicable birth ways to guarantee safety, colour stability, and functional performance are essential for their effective use in food systems.
-

5.2 Natural Food Colour Sources

➢ **Sources Grounded on shops**

- The main source of food colours in shops.
- Carotenoids, similar as lycopene and β- carotene, are fat-answerable and present in carrots, tomatoes, and marigold petals. They give them their unheroic to red colours.
- Berries, grapes, and red cabbage contain anthocyanins(similar as cyanidin and delphinidin), which are water answerable and produce red to blue tinges grounded on pH.
- From beetroot, amaranth, and cacti, betalains(betacyanins and betaxanthins) are set up.

➢ Microbiological Origins

- Through turmoil, microorganisms similar as Aspergillus niger(melanin), Rhodotorula(orange), Spirulina(blue-green), and Monascus purpureus(red colours) are scalable and environmentally benign sources.

➢ Sources Grounded on creatures

- deduced from Dactylopius coccus, cochineal, also known as carmine, produces a deep red colour and is used in yoghurt, delicacies, and authorities.

5.3 Natural Food Colour birth

Pretreatment, solvent birth, sanctification, and stabilisation are all way in the birth process. Solvent type, temperature, pH, exposure to light, and duration are important variables.

➢ **Carotenoids**

- system Hexane or acetone are used to prize the detergent.
- Development For sustainability and chastity, supercritical CO_2 birth is recommended.
- Problem Chlorophyll impurity and oxidation.

➢ **Anthocyanins system**

- Methanol or acidified ethanol.
- Procedure Vacuum attention, filtration, and cold maceration.
- Challenge Extremely heat- and light- labile and pH-sensitive.

➢ **Betalains**

- fashion waterless birth at about pH 4.5. Procedure Spray drying and homogenisation.
- Problem Degrades when exposed to oxygen and heat.

➢ **Chlorophylls Method**

- Water-answerable chlorophyllin is created by stabilising organic detergents(ethanol, acetone) with bobby .
- Challenge When exposed to heat or acid, it transforms into pheophytin.

- **Curcuminoids Method**
- Crystallisation after ethanol birth.
- Increased Yield Employing birth backed by microwave oven or ultrasonography.

5.4 ways for Green birth

- Supercritical Fluid birth(SFE) is a detergent-free system that works well for carotenoids.
- Ultrasound- supported birth(UAE) Shortens time and boosts yield.
- Colour release is better by microwave oven- supported birth(MAE).
- Cellulase and pectinase are used in Enzyme- supported birth(EAE) to ameliorate cell dislocation.
- Natural colourants are getting more and more popular in the food industry thanks to developments in green chemistry, bioengineering, and sustainable sourcing. It's still delicate to guarantee performance equality with synthetic colours, however. Nonstop exploration and development is necessary to enhance heat and light.

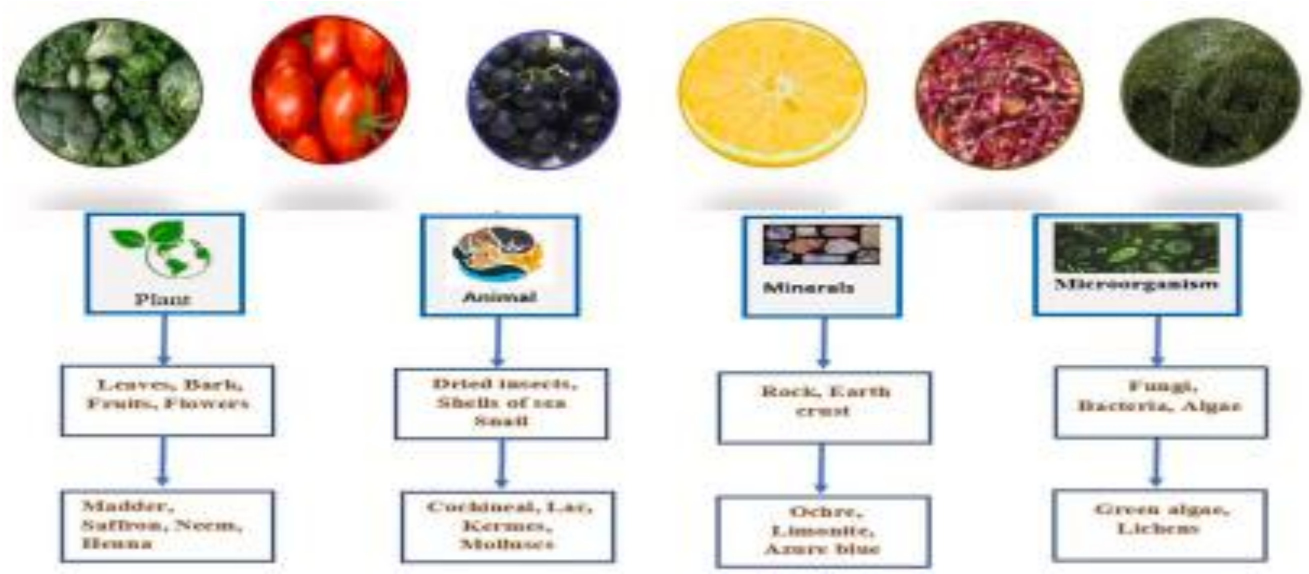


Figure5: SOURCES AND EXTRACTION OF NATURAL FOOD COLOURS

6 APPLICATION OF FOOD COLOURS IN THE FOOD INDUSTRY

A crucial sensory component of food, colour has a direct impact on consumer perception, preference, and purchase decisions. In processed food products, food colors—natural or artificial—are frequently used to support branding, indicate flavour, and improve, restore, or standardise appearance.

6.1 Food Colours Are Important

Colour influences how freshness, flavour, and quality are perceived. Colourants are useful in processed foods where the natural colour may deteriorate:

- Restore the appearance that was lost
- Make sure the batch is consistent.
- Comply with conventional colour standards
- Make novelty or themed products more appealing.

6.2 Important Food Types Employing Colourants

- Drinks: One of the biggest consumers of colour.
- Tartrazine in lemon drinks is a synthetic
- Natural: Beetroot for juices, anthocyanins
- Candy: Colours convey flavour and draw in kids.
- requires stability in pH and heat.
- Problem: When cooking, natural colours may deteriorate.
- Dairy Products: Found in cheese, ice cream, and yoghurt.
- Bakery & Cereals: Colour adds appeal and variation to cakes and cereals.must be able to tolerate baking temperatures.
- Innovation: Natural colours are preserved through microencapsulation.
- Snack Foods: Colours are used to suggest flavour in chips and extruded snacks.
- Carotenoids and other fat-soluble colours are necessary.

6.3 Meat and Alternatives:

- Natural: Pomegranate and beetroot in vegan meat.
- Traditional: paprika, carmine.
- Sauces and Dressings: For instance, ketchup contains lycopene, and mustard contains turmeric.
- Formulation: Needs compatibility with water and oil dispersions.
- Infant & Nutritional Foods: Strict guidelines for child safety; limited use of colour

6.4 Formulation Points to Remember

- Lipid-soluble for fats; water-soluble for beverages.
- Anthocyanins and betalains are impacted by pH sensitivity.
- Stability: Compared to natural colours, synthetic colours are more stable.
- Compatibility: Minerals or proteins may react with natural colours.
- Shelf Life: Encapsulation or refrigeration may be required for natural colours.

6.5 Industrial Difficulties

- Stability: Heat and light cause natural colours to deteriorate (for example, chlorophyll turns brown).
- Cost & Supply: Seasonal supply has an impact on the cost of natural colours.
- Regulations: Need for vegan, halal, and kosher compliance; ethical issues (such as insect carmine).
- Colour Consistency: The climate and geography affect the natural pigments.

6.6 Innovations in Technology

- Microencapsulation: Improves the colour stability of foods that have been dried and heated.
- Oil-soluble natural pigments can be made water-compatible with nanoemulsions.

- By eliminating enzymes that break down pigments, enzymatic processing stabilises them.
- Biotechnology: Consistent, sustainable pigments are produced by microbes.

6.7 Trends in Consumer Behaviour

- Clean Label: Call for identifiable, plant-based components.
- Reducing the use of dyes derived from animals, such as carmine, is part of the vegan movement.
- Functional Benefits: Natural pigments, like curcumin, have health benefits.

Figure6: APPLICATION OF FOOD COLOURS IN THE FOOD INDUSTR

7 HEALTH IMPACT OF SYNTHETIC FOOD COLOURS

Both natural and artificial food colouring are used to ameliorate aesthetic appeal, indicate flavour, or bring reused foods back to their original look. Still, growing consumer, nonsupervisory, and health professional mindfulness has made their goods on mortal health a major concern. Synthetic colourings have constantly been at the centre of toxicological conversations, despite the general perception that natural colourants are safe. This section offers a thorough summary of the clinical data, safety evaluations, and health goods associated with both types of food colouring, including addresses about toxin, behavioural goods, allergenicity, and transnational nonsupervisory reviews.

a. Typical Synthetic Food Colours and Their Health goods a. Tartrazine (E102), a substance present in soft drinks, snacks, and sweets.

- linked to hyperactivity in children (the "Southampton Study").
- can spark antipathetic responses in susceptible individuals, similar as asthma, hives, or migraines.
- limited or outright interdicted in some countries.

b. Sunset Yellow (E110) is a substance that can be set up in delectables, cereals, and gravies.

- linked to behavioral issues in children.
- Some beast studies have reported mild genotoxicity, but mortality data is inconclusive.

c. Red Allura (E129), which is generally present in potables and delectables.

- suspected of causing perceptivity, immunological abnormalities, and hyperactivity.
- within the Acceptable Daily Intake (ADI) ranges that the FDA and EFSA have determined to be safe.

d. Ice cream and delectables contain Brilliant Blue FCF (E133).

- Little is known about the goods of prolonged exposure, despite the fact that it's generally believed to be safe.

e. The red colour erythrosine (E127), which is used in baked goods and canned cherries.

- Contains iodine; devilish consumption may affect thyroid function.
- limited in Europe due to exploration on beasties that encourages the growth of tumors.
- Behaviour and Neurological Problems
- limited in Europe due to exploration on beasties that encourages the growth of tumors.
- Behaviour and Neurological Problems

f. A corner study by McCann et al. (2007) set up that synthetic colourings, especially when combined with sodium benzoate, were associated with hyperactivity in children. Accordingly, the EU now authorizes advisory markers for foods that contain certain synthetic colourings.

- increased scrutiny of children's diets for artificial supplements.
- Although reason is questionable, a number of anecdotal and clinical reports suggest a connection between synthetic food colourings and the following.

g. Attention insufficiency/hyperactivity complaint is pertained to as ADHD. Sleep disturbances and learning disabilities Carcinogenicity and Genotoxicity. Some synthetic colourings, similar to Red 2G and amaranth, are banned in numerous places because they may beget cancer in breast models. DNA damage due to broken azo bonds is one of the possible mechanisms. creation of poisonous sweet amines. oxidative stress associated with colour metabolism.

7.1 Goods of Natural Food Colours on Health

Natural colours are generally allowed to be safe because they appear from shops, microbes, or beasties. Still, they are not risk- free. Overconsumption, immunological responses, and pollutants can all be causes for concern.

a. Common Natural Colours and Safety Features a. Curcumin, a substance set up in turmeric

- anti-inflammatory and antioxidant.
- generally regarded as secure (GRAS).
- Overuse can beget stomach torture and interfere with anticoagulants.

b. Betanin, or beetroot red, is safe and good for antioxidants.

- Beeturia, or red urine, which is constantly mistaken for blood, can be caused by overconsumption.

c. The high antioxidant content of anthocyanins, which are present in berries and grapes.

- There was no egregious bane, indeed, at high tablets.
- could ameliorate cardiovascular health.

d. Chlorophyllin semi-synthetic outgrowth of chlorophyll.

- Non-toxic and deodorizing.

e. In susceptible individuals, carmine, which is present in cochineal insects, can beget severe antipathetic responses, including anaphylaxis.

- Not suitable for vegan, halal, or kosher patrons.

7.2 The Allergenicity of Natural colourings

- Some factory colours can spark antipathetic responses, despite their oddity
- Annatto rarely results in urticaria or angioedema.
- Carmine Strong IgE-mediated responses do in sensitive individualities.
- Excerpts from paprika May spark responses in capsicum-antipathetic individuality

7.3 Issues with Processing and adulterants

- Two implicit pollutants of natural colours are fungicides and heavy substances (if sourced inaptly).
- impurity during turmoil or birth by microorganisms.
- solvent remainders from chemical processing.

7.4 Monitoring for Safety and Regulation

a. The FDA (U.S.) classifies food colouring agents as either pukka (synthetic) or pure from an instrument (natural).

- demands a batch instrument for synthetic colourings.

b. All food complements were reexamined by EFSA (Europe) after 2010.

- insists on advising markers for specific colourings linked to hyperactivity.
- Only authorized colours with strict safety lives are allowed.
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c. The FSSAI (India) only allows a limited range of synthetic colours with specified maximum operation situations.

- Promotes the use of natural colouring in reused foods.
- Trouble operation and Monitoring
- After-request surveillance Mechanisms for telling unfavorable incidents keep an eye on antipathetic or poisonous responses.
- Synthetic or mislike-causing colourings are now demanded in numerous countries.
- Frequent reevaluation Considering new scientific discoveries and operational trends.
- Thus, to ensure safety, standardization, quality control, and food-grade instruments are vital.

7.5 Toxicological Evaluation ways

- Beast models are used for both acute and long-term bane testing when assessing the safety of food colouring.
- Tests for genotoxicity and mutagenicity.
- Harmfulness to reduplication and development.
- Exploration of carcinogenicity.

7.6 Respectable quotidian input (ADI)

- Regulatory agencies define respectable exposure situations, or ADIs.
- Milligrams per kilogram of body weight per day is how ADI is calculated.
- ADIs are reckoned from NOAEL (no observed adverse effect position) in beast studies with spare safety considerations.

  For example, the EFSA states that the ADI for tartrazine is 0–7.5 mg/kg bw/day.

7.7 Consumer Safety and mindfulness

- Growing consumer mindfulness has led to a demand for "free-from-artificial-colour" products.
- Reading food markers more nearly.
- Parents prefer children's products that do n't contain colourings.
- Natural and organic foods are growing in popularity.

7.8 Arising Problems and exploration Faults

- Long- Term Exposure goods
- It's still unclear how food colour Gut
- Recent studies suggest that artificial colourings may disrupt the gut microbiota's equilibrium, which may impact digestion, immunity, and internal health.
- Interaction with Other medicines
- Combining artificial colouring with preservatives or sweeteners may have a synergistic effect on health, adding the trouble of bane or aversions.

8 Conclusion And Future Prospects

The long-standing human desire to improve the visual appeal of food is reflected in the development of food colouring, from ancient natural plant extracts to contemporary synthetic dyes. The sources, classifications, chemistry, uses, health effects, laws, and advancements pertaining to natural and artificial food colouring have all been critically analysed in this study. These findings are summarised in the conclusion to give stakeholders in the food industry, academia, and policy-making a fair perspective.

8.1 Contrast and Coexistence

The functions of artificial and natural food colouring are different but complementary. People believe that natural colors are healthier, better for the environment, and consistent with the clean-label movement. However, especially for large-scale manufacturing processes, synthetic colors are more vibrant, stable, and economical.

1. A "good vs. bad" division is very straightforward. When selecting the right colourant, manufacturers must consider factors like cost, safety, consumer trends, and processing requirements. Complete substitution is less realistic than pragmatic coexistence.

8.2 Changing Customer Preferences

Market demand is changing as a result of consumer awareness. Because people are becoming more skeptical of synthetic dyes, natural dyes that are marketed as organic, chemical-free, or plant-based are becoming more and more popular in developed countries. Urban health-conscious consumers are increasingly choosing natural alternatives for baby formulas and nutritional supplements, even though synthetic dyes are still frequently used in developing nations like India because they are less expensive.

Labelling, ethical marketing, and transparency are becoming just as important as price and performance.

8.3 Aspects of Safety and Health

Because of possible associations with allergies, hyperactivity, and cancer, synthetic colours have come under scrutiny. Strict labelling regulations, safety evaluations, and intake limits have been implemented in response by regulatory bodies such as the FDA and FSSAI.

In general, natural colors—especially those derived from GRAS sources—are safer. They are not risk-free, though; some can cause allergies or deteriorate in the presence of heat and light. Scientifically supported risk-benefit analyses are crucial for well-informed decision-making.

8.4 New developments Overcoming the Divide

The gap between natural and synthetic dyes is being closed in part by new technologies. Through the use of state-of-the-art biotech tools such as CRISPR and microbial fermentation, it is possible to produce natural-colour pigments with synthetic-like characteristics. By employing different methodologies including methods like co-pigmentation and nanoencapsulation these approaches not only stabilize pigment colour but also increase pigment solubility, putting a and on once again encouraging opportunities to produce colourants that are bold, safe, biodegradable and consumer desirable.

8.5 Ethics and Sustainability

Sustainability is turning into a crucial evaluation factor. While synthetic dyes are frequently derived from petrochemicals and contribute to industrial pollution, natural dyes made from agricultural waste or renewable sources support the objectives of the circular economy.

Ethical considerations are also important. Cochineal, for example, is a natural dye that is inappropriate for vegans and members of certain religious communities. Observance of Kosher, Halal, and ethical sourcing guidelines.

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10 APPENDIX

1. Which category best describes your background?

a) General consumer
b) Food science student
c) Food industry professional
d) Health professional

2. Are you familiar with the difference between natural and synthetic food colours?

a) Yes, I understand both types clearly
b) I have heard of them but don't know the differences
c) I know a bit about natural colours only
d) I'm not familiar with either

3. How often do you consciously choose products with natural food colours?

a) Always
b) Sometimes
c) Rarely
d) Never

4. Which of the following sources of natural colours are you aware of?

a) Plants and herbs
b) Insects (e.g., cochineal)
c) Microorganisms (e.g., Monascus)
d) All of the above

5. Which of these synthetic food colours have you heard of?

a) Tartrazine (Yellow No. 5)
b) Allura Red (Red No. 40)
c) Brilliant Blue (Blue No. 1)
d) None of the above

6. Do you believe natural food colours are healthier than synthetic ones?

a) Yes, definitely
b) Possibly, but I'm not sure
c) No, health risk is similar
d) I've never considered this

7. What factor most influences your preference for natural colours?

a) Health and safety
b) Environmental sustainability
c) Cultural or religious reasons
d) Marketing and product branding

8. What is the main reason you think manufacturers use synthetic colours?

a) Cost-effectiveness
b) Better colour vibrancy and stability
c) Easy availability
d) All of the above

9. Would you accept less vibrant-looking food if it contained only natural colours?

a) Yes, completely
b) Yes, to some extent
c) No, I prefer vibrant colours
d) Depends on the product type

10. Are you aware that some natural colours are extracted from animal sources like insects (e.g., carmine)?

a) Yes, and I avoid them
b) Yes, and I am fine with it
c) No, this is new information
d) Not sure

11. Do you think synthetic colours should be banned if equivalent natural alternatives exist?

a) Yes
b) Only in specific products (e.g., children's food)
c) No, they are still useful
d) I don't have an opinion

12. Which food category do you think relies most on synthetic colours?

a) Soft drinks and juices
b) Candies and confectionery
c) Processed snacks and chips
d) All of the above

13. What is your biggest concern about natural food colours?

a) Poor heat/light stability
b) Limited colour range
c) Higher cost
d) None; I fully support them

14. Which modern technique in natural colour production are you most interested in?

a) Microbial fermentation
b) Supercritical fluid extraction
c) Nanoencapsulation for stability
d) I'm not aware of these

15. If given the choice, would you support food companies investing more in natural colourants despite higher production costs?

a) Yes, for health and environmental reasons

b) Yes, if the product quality remains unchanged

c) No, it would increase prices

d) Not sure