e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss 1, 2022
 UGC CARE Listed (Group -I) Journal

FOOD BASED NATURAL DYE FOR COTTON FABRIC: A STEP TOWARD SUSTAINABILITY

Gurpreet Kaur

Assistant Professor, Department of Fashion Technology,

Multani Mal Modi College, Patiala, India.

reetsandhu00038@gmail.com

Abstract: The advent of synthetic dyes brought a revolution in the dyeing industry since they provide several advantages over natural dyes from a business point of view which include a wider range of colors, reduced manufacturing costs and better color consistency But on the other hand, synthetic dyes are inherited with various environmental issues as the dyeing process results in the production of genotoxicity and aquatic toxicity material Nowadays, the use of natural dyes is in fashion and people start preferring natural dyne over synthetic dyes The present study is an attempt to explore various procedures and methods to prepare natural dye from kitchen food and vegetables The objective of the research is to develop natural dye from kitchen waste based on the idea of sustainability of the environment, utilization of renewal nature of materials and reduced environmental damage.

Keywords: Natural Dyes, Sustainable Environment, HerbalTextile, Kitchen Waste Dye.

1. Introduction

Nowadays, many customers prefer natural herbal textile dyes over synthetic dyes because fabric dyes with herbs offer a non-toxic, chemical-free product that is safe for both people and the environment. Natural dyes are available in a wide range of forms and have been utilized by humans for thousands of years. Global historical facts about natural dyes revealed that the cave paintings at Altamira in Spain and Lascaux in France were created 15,000 years ago using natural dyes and paints. Ancient Chinese, Indian, and Egyptian dyers found sources of rich dyes in plants and animals between 4,000 and 3,000 B.C. To create complex compounds the majority of natural colours were fixed using metal salts including alum, cuprous sulphate, and ferric sulphate. Tannin was a commonly used organic mordant that helped fabrics fix dyes (Bhattacharya**,** 2000**)**. Natural dyes required a lot of labour to develop and utilize, so they weren't commonly used until the creation of the first synthetic dye, Mauveine. William Perkin attempted to create a quinine alternative in 1856. This purple dye

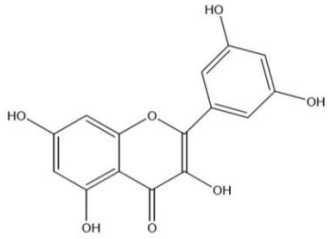
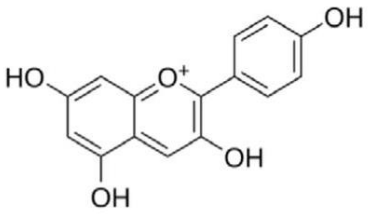
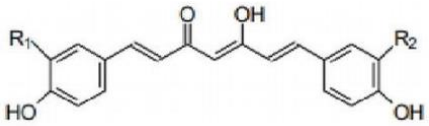
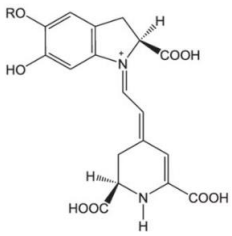
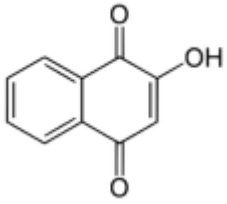
was created using precursors from coal tar, which later served as the basis for numerous synthetic colours. Diazo compounds, which were initially discovered in 1858, served as the precursor of aromatic azo compounds, the largest family of synthetic dyes currently in use. As a result, the demand for natural dyes was essentially supplanted by large-scale synthetic dye production. Different synthetic dyes were found that covered a wider range of the colour spectrum, were more affordable and could be used on a wider variety of materials. But later on, stakeholders realized that the synthetic dyes procedure results in contamination of the environment and is also harmful to inhabitants. A shift has been seen towards herbal nontoxic dyes that not only protect people but have some additional health benefits. The present study experimented with kitchen waste material to develop a natural dye that may provide consistent and stable performance. The following section covers a detailed analysis of various classifications of dyes with their compositions and the next section incorporates a detailed discussion of the experiments conducted in the present study.

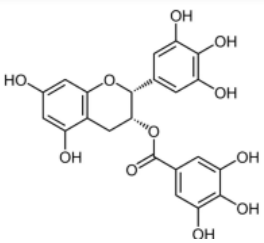
1.1 Classification of Natural Dye

There are three categories of natural dyes used to colour clothing. When a fiber is dyed where mordant doesn't require to fix colour and that forms a direct bond with the fiber. Typically, the structures of these dyes include mordants such as extracts from tea, black walnut, and onion peel **(Verma and Gupta, 2017).** The second type is traditional dyes, which comprise the majority of the natural dye family. For the dyes to be fixed to the fiber in this group, a metal-fiber complex must form. Examples of plants that contain the basic building blocks of alizarine include madder, kermes, and lac. Vat dyes comprise the third group. These dyes, which include indigo and Tyrian purple, are water-insoluble but can be made soluble and diffused into fiber by using alkali and sodium hydrosulfite **(Haji, 2019).** Another kind of classification is also in practice that is based on origin i.e. Vegetable, Animal based and Mineral. The following are some classifications for dye. Table1 shows the chemical name and extraction procedures of some of the dyes used in the experiments.

e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss 1, 2022

Table1: Chemical name and extraction procedure

Molecular structure	Classification of Natural Dyes
 Morine (3,5,7,2′,4′pentahydroxy-flavone)	**Jackfruit (Artocarpus heterophyllus Lam):** It contains the coloring component morin and has been used to colour cotton and jute fibers. The wood of the Jack fruit is the dye's source. Wood was chopped into small chunks and prepared powder to extract the colour. The powder is subsequently boiled in water to achieve the desired hue (Qadariyah, 2017).
 Pelargonidin (5,5,7,4 Tetrahydroxy Antocyanidol)	**Onion (*Allium cepa*):** The layers or peels of the onion are peeled and utilized to extract colour. Boiling these materials produces the colour pelargonidin, which ranges from orange to brown (Gupta, 2019).
Curcuma longa  Diarylheptanoid	**Diarylheptanoid(Turmeric)** To extract the colour, the turmeric root is dried, ground into a powder, and then boiledin water. It is a dye that can be used on cotton, wool, and silk. After using turmeric's natural dye, a dazzling yellow colour is produced. Curcuminoids, a class of phenolic chemicals, are abundant in turmeric. Curcumin is the name of the coloring agent in turmeric (Salemet al.,2020).
 **Betanin**	**Betanin (Beetroot Dye)** Beetroot, often known as beets, is a well-liked root vegetable that is utilized in a variety of international cuisines. The primary colouring agent in red beetroot juice is beetroot (**Ghosh et al.,2022).**
Mehedy/Henna leaf dye 	**Henna Leaf** Mehedy, a natural dye made from plant leaves, is what is referred to as henna. Since ancient times, henna has been most frequently used to colour cotton, silk, wool, and other fibres as well as skin, hair, and fingernails (**Ghosh et al.,2022).**

 **Tea Lea**	**Tea Leaf** Tea is a liquid product with a sweet aroma that is made by pouring boiling water into a cup. The dyeing of fabrics, fibres, and yarns now use this naturally occurring color-bearing chemical (**Ghosh et al.,2022).**

Mordants for natural dyes:A natural dye mordant could be any of some metal salts that can create a chemical link between the dye and the fabric. They increase the colour fastness of the coloured clothes by bonding with dyes more readily than the fibers. Before the 19th century, transition metals like Cu2+ and Cr6+, which are currently discouraged due to their environmental toxicity, were the majority of the mordants utilized **(Mishra and Gautam, 2020).**

In recent studies, aluminum, iron, and tin were chosen as metal mordants with an eco-friendly approach in mind to remove the potential harm to human health and the environment. Tin is notably utilized to produce brighter colours; nevertheless, because it makes cloth brittle and harsh to the touch, it may cause damage.

Harvesting natural dyes: Natural colours are relatively sparsely distributed in natural items. To remove the dye from its source, they need a specialized procedure. Here are a few techniques that work well for extracting natural colours from their raw ingredients **(Samanta 2020)**.

Water-based extraction: This technique involves powdering or breaking down the dye-containing materials into little pieces, which is followed by an overnight soak in water. For non-dye components to be removed, it is boiled and filtered. To get rid of tiny pollutants, trickling filters are also employed occasionally. This method's drawback is that some of the dye breaks down while it's boiling. Therefore, this approach works with colours that do not degrade at boiling temperatures. The molecules should dissolve in water (**Hamdy et al.,2021)**.

Acid and alkali extraction: The natural dye from the ‘Tesu’ flower is extracted using an acidic hydrolysis process. Alkaline solutions work well with dyes that have phenolic groups built into their composition. This technique can be used to extract dyes from annatto seeds.

Using this technique, red dye from safflower and lac dye from lac insects are also extracted **(Kiumarsi et al.,2017).**

Ultrasonic microwave extraction: Natural dye extraction benefits from the use of microwave and ultrasonic waves. This method has several benefits over aqueous extraction. Less solvent (water) is needed for extraction with this method. Compared to an aqueous extraction, the process takes less time and a lower temperature. Aqueous solutions of natural dye are subjected to ultrasonic and microwave radiation, which accelerates the extraction procedure (**Mason** et al.,2021).

Fermentation: The fermentation of naturally coloured compounds accelerates in the presence of bio enzymes, and natural colours are extracted. The fermentation process of extraction is best illustrated by the extraction of indigo. The 'indimulsin' enzyme breaks down the glucoside indican into glucose and indoxyl. Natural dyes are extracted from bark, stems, and roots using cellulose, amylose, and pectinase (**Srivastava and Singh, 2019).**

Vapor extraction: To extract natural colors, organic solvents like acetone, petroleum, ether, chloroform, and ethanol are used. Comparatively speaking aqueous extraction, is a relatively viable method. The amount of water needed is minimal, and the dye production is good. The lower temperature is used for the extraction.

1.2 Enviromental and health perfective of natural dye

Alum (natural mordant alum to skin) is a well-known astringent that has miraculous effects on the skin and helps to minimize and tighten pores. By limiting bacterial growth and irritation, it protects the skin from bacterial infection. It works as an antiperspirant deodorant because it has a great ability to reduce sweating.

- **Black Tea:** Black tea is also rich in caffeine content as coffee which helps to fade away blemishes, dark circles, and delay skin aging due to skin cleaning properties. Dying with back tea is the eco-friendly method as it contains a high level of tannin which acts as a mordant(Mishra & Gautam,2020).
- **Coffee:** Coffee is a great source of vitamin B3 (niacin) which help to prevent skin cancers and also helps to reduce redness, sunspots, inflammation and dark circles & providing smooth skin. Coffee's caffeine component helps to even out skin tone by reducing the appearance of cellulite.

- **Mint:** Salicylic acid, which is present in mint prevents acne, functions as a mild astringent and skin toner, and also cleans pores by eliminating debris. Due to the antioxidants in the product, which also protect the skin from rashes, brighten the complexion and help to decrease dark circles. It produces a natural green (mint-green) color on fabric (Srivastava and Singh,2019).
- **Bitter Ground:** Antioxidants, vitamins A and C, are abundant in the bitter ground. These qualities help to combat deep skin infections like itching, psoriasis, and eczema. It provides acne-free skin and supports the growth of skin cells. It is employed as a natural dye in Ayurveda to create cold, greenish hues.
- **Rhubarb Flower:** It has inherent antibacterial and antifungal effects. It reduces the number of infections. Oxalic acid makes the light brown hue persist longer because it is present. It is also renowned as a natural hair dye.
- **Turmeric:** One of the first natural dyes used in the textile industry, it used to give cotton cloth golden hues. owing to its antimicrobial, anti-inflammatory, anti-bacterial, and rich source of antioxidant capabilities. It is frequently utilized in the manufacture of cosmetics since it aids in the reduction of skin issues like stretch marks, wound healing, puffiness, and skin discoloration(Aggarwal, 2021).

  Onion: There are several skin-friendly acids and chemicals in onions. It's abundance of antioxidants reduces surgical scarring and fights free radicals. Due to its polyphenols' ability to brighten and soften skin. Additionally, onions have antibacterial and antiseptic characteristics that can combat fungus and bacteria. In the cosmetic industry, onion masks for moisturizing and brightening skin are frequently used. Using onion skin to create different colours on various fabrics is relatively affordable(Zubairu et al.,2015).

  Beetroot: Beet juice is frequently used as a natural colourant to create shades on cotton fabric. It is an excellent source of vitamin C and serves as a cheek and lip tint. It has a high vitamin C content, which makes it anti-aging. It can be applied to the skin to remove dead cells, treat acne, lessen dark spots and circles, and repair the skin, leaving it with a flawless glow and smooth, silky skin(Aggarwal, 2021).
- **Pomegranate:** Pomegranate is a high source of vitamin C, which can battle against sunspots, pigmentation, and give skin a healthy glow. Oily and acne-prone skin can

benefit greatly from pomegranate washes and serums. The oldest fruit is frequently used as a natural colouring ingredient to create colours(Aggarwal, 2021).

- **Cardmom water**: Cardamom is a natural moisturizer that also has anti-bacterial, anti-inflammatory, and antiseptic qualities. It also has a significant amount of vitamin C. These all work together to prevent allergies, treat acne, purify the skin, get rid of blemishes, and level out the skin tone, so card mama has amazing skin effects. It can treat skin infections and allergies. It also aids in the fabric's ability to absorb dye consistently and to avoid unpleasant odors. (Vankar er al.,2019).

2. Experiments with natural dyes based on kitchen food

The study has been conducted to develop natural dye out of kitchen food waste and apply the natural dye to cotton fabric. The performance of the natural dye has been evaluated based on standard metrics.

Dyeing process: Pure bleached cotton with plain weave structure fabric has been used for the dyeing process. First, the fabric is soaked in cardamom water for 45 min so the fabric catches the dye color consistency and prevents skin problems. Natural mordant Alum(app 10% alum according to the weight of fabric) and water are boiled together for 45 min at 100^{o} degrees centigrade for better absorption. After drying the fabric under sunlight samples were collected for actual dyeing with natural dyeing material. For the present study, we have used Dye-1(Onion), Dye-2(Beetroot), Dye-3(Rhubarb Flower), Dye-4(Black Tea), Dye-5(Bitter Ground), Dye-6(Pomegranate), Dye-7(Mint), Dye-8(Turmeric) and Dye-9(Coffee). Dyeing of cotton fabric was done with natural coloring matter extracted from Bitter ground, Black tea, Coffee, Turmeric, Onion, and Beet Root with a Liquid ratio of 1:30 at 100^{o} degrees centigrade for 1hr.

The dyeing process was performed in a stainless-steel vessel. After dyeing cloths were dipped in cardamom for 10-20 min. Cardamom water helps to suppress any odor due to dye material like onion etc. and cardamom has antibacterial and anti-inflammatory, anti-septic properties as a natural moisturizing agent. These qualities help to prevent allergies and heal acne, purifying skin clean.

Natural dyes' fastness qualities

Fastness qualities are one of the dyeing quality criteria. There are several test procedures published to determine color fastness. The fastness characteristics provide insight into the dyeing's quality. The substrate type and mordant employed for dyestuff fixation have a significant impact on the fastness properties of natural dyes. In addition to the dye itself, several other elements like as water, chemicals, temperature, humidity, light, pretreatments, posttreatment, the distribution of the dye in the fabric, and dye fixation affect the fastness qualities (Shariful et al.,2020). The colour and fastness of natural dyes in natural dyeing require special consideration for careful selection of materials and procedures. Up until the end of the nineteenth century, natural dyes were used. The use of natural dyes for dyeing was at its height during that time.

Light fastness: Natural dyes have poor to moderate lightfastness. Due to chromophoric change in dye structure upon light absorption, there is poor light fastness. The energy collected by resonance cannot be easily released by the chromophoric groups due to their weakness **(Prabhu and Bhute, 2012)**. Cook published a thorough analysis of the development of the light resistance of dyed textile fibers. The researched the application of tannin-related post-treatments on mordantly dyes to be used in cotton dyeing for boosting light and wash fastness, and his discoveries helped enhance the fastness features of natural dyed materials. The light stability of natural dyes is inferior to that of synthetic dyes. Wool coloured with nine natural dyes, including: was examined by Padfield and Landi for its lightfastness.

Washing fastness: Natural colours are either poorly or moderately resistant to washing. Due of the extremely low connection between dye and fiber, colours do not react with washing solutions very quickly.

Rubbing fastness: The experiment has been conducted using ENISO-105 x 12 with equipment Crok Meter, special rubbing cotton of size (5x5). The following procedure has been followed:

- Fix the specimen (natural dye cotton cloth) onto the base of the Crock meter.
- Set 5x5 cm sample of clean cloth on the finger of the crock meter using a spinal spring.

- Lower down the finger which is covered with the white specimen and focus it on the dye material fixed on the base of the Crock meter.
- Now, turn(run) the hand crank at the rate of 10 x 10 sec (10 Times).
- Remove the white cloth from the finger.
- Using grayscale record the reading of the sample.
- Repeat the above steps for all the samples and relocate the cloth on the base for fresh reading.

3. **Experience and Data analysis:** The experiment of natural dyeing has been conducted on cotton fabric with 9 natural dyes. A sample of 90 cotton fabric and 10 samples of each dye have been analyzed. After dyeing, the colour fastness of the dyed materials was tested. The fastness of textile substrates to factors including light, washing, and rubbing was assessed throughout the dyeing process. Crockmaster (James head) with AATCC method was used to access the rubbing fastness and change in shade.

The test for light fastness was conducted using an outdoor exposure cabinet. The specimens are shielded from the elements by a glass-covered wooden enclosure in the cabinet. The cabinet was covered once these specimens had been set up on the rack. The samples were then left out for seven days in the sun between the hours of 10 a.m. and 4 p.m.

Following are a few sample images of natural dye.

Table2: Samples of natural dye fabrics(Dry and Wet)

1. Onion (Dry)

2. Beetroot (Dry)

3. Rhubarb flower (Dry)

4. Black Tea (Dry)

5. Rhubarb Flower (Wet)

6. Bitter Ground (Dry)

7. Pomegranate (Wet)

8. Black Tea (Dry)

9. Mint (Dry)

10. Turmric (Wet)

11.Turmric (Dry)

12. Coffee(Dry)

The sample has been tested for quality by four parameters i.e. color fastness, light fastness, washing fastness and rubbing fastness. The following table shows the results of these parameters:

Table3: Results of fastness test on natural dye

	Average Scores of Testing Parameters (1-5)				
	Color Fastness	Lightfastness	Washing fastness	Rubbing fastness	
				Wet	Dry
Dye-1(Onion)	4	3	3	2-3	3-4
Dye-2(Beetroot)	4	3-4	3-4	2-3	2-3
Dye-3 (Rhubarb Flower)	3-4	3	3-4	3	3
Dye-4(Black Tea)	4.1	4	3-4	3	4

Dye-5(Bitter Ground)	4-5	4	3-4	3	4
Dye-6 (Pomegranate)	4-5	4-5	4	3	4
Dye-7(Mint)	4-5	4	4-5	2	4
Dye-8(Turmeric)	4-5	4	4	3	3
Dye-9(Coffee)	4-4	4	4	3	4

Fastness rating 1 = Very poor, 2=Poor, 3=Fair, 4=Good, 5=Excellent (Lyle, 1977)

The sample has been evaluated using the grading scale (1=Lowest to 5=Highest) for the four parameters. From the table2, it appears that all of the dyes have been rated above average, and the outcomes are satisfactory.

4. Conclusion:

India is one of the nations with abundant plantations which contribute towards natural wealth. So, there also are plenty of raw ingredients available to make natural dyes. Moreover, the majority of Indian survive on a vegetable diet and waste out of the kitchen can easily be used for making dye at home. Kitchen food-based natural dyes have no risks and do not hurt human skin as compared to chemical dyes. The study analyzed various natural dyes extracted from food and vegetables and also conducted quality testing. It has been revealed from the testing that all the five natural dyes used in the experiments found in good quality in terms of color fastness, light fastness, washing fastness and rubbing fastness. The study concluded that natural dyes can be successfully extracted from vegetable waste and can be easily used to dye cotton stuff.

5. References

Aggarwal, Shilpi. "Indian dye yielding plants: Efforts and opportunities." In Natural Resources Forum, vol. 45, no. 1, pp. 63-86. Oxford, UK: Blackwell Publishing Ltd, 2021.

Bhattacharya, S. D., & Shah, A. K. (2000). Metal ion effect on dyeing of wool fabric with catechu. Coloration Technology, 116(1), pp.10-12.

Ghosh, S., Sarkar, T., Chakraborty, R., Shariati, M. A., &Simal-Gandara, J. (2022). Nature's palette: An emerging frontier for coloring dairy products. Critical Reviews in Food Science and Nutrition,pp. 1-45.

Gupta, V. K. (2019). Fundamentals of natural dyes and its application on textile substrates. Chemistry and technology of natural and synthetic dyes and pigments, 2019.pp.43-65.

Haji, A. (2019). Dyeing of cotton fabric with natural dyes improved by mordants and plasma treatment. Progress in Color, Colorants and Coatings, 12(3), pp.191-201.

Hamdy, D., Hassabo, A. G., & Othman, H. A. (2021). Various natural dyes using plant palette in coloration of natural fabrics. Journal of Textiles, Coloration and Polymer Science, 18(2), 121-141.

Kiumarsi, A., ParvinzadehGashti, M., Salehi, P., &Dayeni, M. (2017). Extraction of dyes from Delphinium Zalil flowers and dyeing silk yarns. The Journal of the Textile Institute, 108(1), 66-70.

Mishra, A., & Gautam, S. (2020). Application of natural dyes for herbal textiles. Chemistry and technology of natural and synthetic dyes and pigments, pp.123-50.

Prabhu, K. H., &Bhute, A. S. (2012). Plant based natural dyes and mordants: A Review. *J. Nat. Prod. Plant Resour*, *2*(6), 649-664.

Qadariyah, L., Gala, S., Widoretno, D. R., Kunhermanti, D., Bhuana, D. S., Sumarno, & Mahfud, M. (2017, May). Jackfruit (Artocarpus heterophyllus lamk) wood waste as a textile natural dye by micowave-assisted extraction method. Vol. 1840, No. 1, p. 100007.

Salem, M. Z., Ibrahim, I. H., Ali, H. M., & Helmy, H. M. (2020). Assessment of the use of natural extracted dyes and pancreatin enzyme for dyeing of four natural textiles: HPLC analysis of phytochemicals. *Processes*, *8*(1), 59.

Samanta, P. (2020). A review on application of natural dyes on textile fabrics and its revival strategy. *Chemistry and technology of natural and synthetic dyes and pigments*, 1-25.

Shariful Islam, S. M., Alam, M., &Akter, S. (2020). Investigation of the color fastness properties of natural dyes on cotton fabrics. *Fibers and Textiles*, *27*(1),pp.58-68.

Srivastava, R., & Singh, N. (2019). Importance of natural dye over synthetic dye: a critical. International Journal of Home Science, 5(2), 148-150.

Vankar, Padma Shree, and Dhara Shukla. New trends in natural dyes for textiles. Woodhead Publishing, 2019.

Verma, S., & Gupta, G. (2017). Natural dyes and its applications: A brief review. *International Journal of Research and Analytical Reviews*, *4*(4), pp.57-60.

Zubairu, Abdu, and Yusuf Madu Mshelia. "Effects of selected mordants on the application of natural dye from onion skin (Allium cepa)." Science and Technology 5, no. 2 (2015): 26-32.