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DYEING AT HOME FROM KITCHEN WASTE - TEA AND COFFEE RESIDUE

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ABSTRACT

Food and Textile industries are considered to be the most vital industries for human survival. The food industry generates an enormous amount of waste which is used as animal feed or undergoes composting or just go as landfills. Some of these organic wastes contains colouring pigments which can be effectively used to colour textiles. Hence there is a possibility to bridge the gap utilizing the waste from food industry to colour textile materials. Chemical dyes are easier to use and produce bright shades but on the other hand it causes pollution to the environment. Natural dyes from plant sources are required in large amounts which may cause depletion of natural resources. Considering these factors, the waste material from food industry, which is available at little, or no cost can be effectively used to colour textiles, this would make natural dyeing affordable and bring about sustainability in textile dyeing process. This kind of sustainable approach protects the environment by utilizing the waste produced by one industry and creating a value-added item for another industry. This study was carried out considering the sustainability aspect which is mutually beneficial to food and textile industries.
Natural dyes can be found in the kitchen or in one's garden can produce beautiful hues. A simple dyeing process can be used to colour the fabric at home utilising available resources in the home kitchen. Decoction waste after extracting two widely used beverages - tea dust and filter coffee dust which are part of everyday kitchen waste were used for the study. Instead of these wastes going directly as landfills, dye was extracted prior to its disposal. Cotton fabric, mordanted with Alum, was dyed with the extracted dye. These dyed fabrics showed good to excellent colour fastness to perspiration, rubbing, washing, and pressing. Since these dyes are natural in origin, they are safe and eco-friendly. This study proves that throw-away kitchen waste can be utilized to extract dyes that can be used to create value-added products.

Keywords: Organic Waste, Natural Dyes, Sustainable, Value-Addition

1. INTRODUCTION

Solid waste generated from industries, agriculture, and houses mostly goes as landfills in developing countries which is of great environmental concern. Hence a sustainable approach to solve this problem is necessary in the management of solid wastes. The unused portions of fruits or vegetables, leftover portions from household kitchens, restaurants, etc. contain organic matter in high amount which can be considered as a source for creating value-added products before it goes as a landfill.

2. WASTE FROM KITCHEN

Vegetable wastes, such as shells, peels, scrap, etc, occur during various processes in the vegetable supply chain. It is estimated that around 30 percentage

of vegetable waste occurs during the consumer level globally. Out of which about 80 percentage occurs during post-harvest and subsequent food processing. Consumer usage of vegetables in households, canteen, and restaurant account for the remaining 20 percentage Rais & Sheoran (2015).

Today, the waste generated in the household contributes to environmental threats and ways to develop a model to recycle the waste in possible areas is the need of the hour. This kitchen waste has the potential to function as a source of extraction of natural dyes AshishT et al. (2020). The kitchen waste disposal in a way that does not create a bio-burden is looked upon all around. Utilizing kitchen waste for extracting dyes is beneficial, as usage of natural dyes will also have a positive impact on the economic growth of the rural dyers Jain et al. (2021).

3. NATURAL DYES

The earliest form of colouring textiles was using Natural dyes. Since ancient times natural dyes have been used for colouring body, food, walls of caves, leather, and textiles Křížová (2015). The use of natural dyes from plants can be traced back to 2600 B.C. in China. Based on the archeological evidence, initially only a small number of plants and animals were used as sources to extract natural dyes Che & Yang (2022).

Natural dyes, can be derived from varies parts of plants like roots, stems, leaves, flowers, fruits; Also, from animal sources and natural-coloured ores. Dyes can be obtained from other sources like fungi, snails, insects, etc Tamilarasi & Banuchitra (2021). The beneficial aspects of using natural dyes are manifold as they are eco-friendly, safe, easily obtained from renewable sources and gentle to the human eye. These dyes do not cause any health hazards and do not create any disposal problems. India is a rich source of colorants, there are around 500 varieties of plants from which dyes can be easily extracted Yadav et al. (2023).

Dyes obtained from natural sources are pleasant and can be used instead of synthetic dyes due to its environmental benefits Yusuf & Shahid-ul-Islam (2017). The colouring component present in most of the natural dyes, is only a small amount of its total solid weight. Hence a huge amount of the raw material is necessary to dye a small quantity of textiles. Since a huge amount of the dye source is required for the extraction of dye, it may result in overexploitation of the natural resources. Lot of efforts have been undertaken globally to address the limitations of natural dyes and find alternate sources because of their tremendous advantages to the environment Kulkarni et al. (2011). Waste material, available at no or little cost, can be used as an alternate source for natural dyes that makes it cost-effective and affordable and brings about sustainable approach in textile dyeing process.

4. NATURAL DYES FROM TEA AND COFFEE RESIDUES

The use of natural resources to colour textiles might lead to the depletion of the same. Hence the present study was undertaken as an exploratory study to extract dyes from waste which is generated every day from the home kitchen, at no cost and easily available. It focuses on ways to upcycle the kitchen waste by extracting dyes from the two popular and widely used beverages namely tea and coffee residues after the beverage extraction. Black Tea (Camellia sinensis) and Coffee are the most widely consumed non-alcoholic beverages in the world. The major polyphenolic compounds present in black tea are Theaflavins and thearubigins. So far more than 25 theaflavins are found in black tea Koch (2020).

The decoction waste, before it goes as a landfill, is used in the extraction of colour to dye the textile material hence adds value to the product. Simple dyeing process which could be carried out at home was adapted in the study which can be done in the convenience of available resources. Colourfastness tests and antimicrobial analysis were carried out to find the efficiency of the dyes. The qualitative phytochemical analysis of the Tea and Coffee extracts were also carried out to confirm the presence of phytochemicals.

5. OBJECTIVES OF THE STUDY

1) To mordant the cotton fabric with a natural mordant - Alum (Potassium Aluminium sulfate).
2) To extract natural dyes from throw away beverage waste – Tea extract and filter coffee extract.
3) To dye the mordanted cotton fabric with the Tea extract and filter coffee extract.
4) To evaluate the colourfastness of the natural dyed fabric to Laundering (40o C), Light, Pressing (Dry, Damp and Wet) Perspiration (acidic and alkaline) and Crocking (Wet and Dry).
5) To estimate the depth of shade and the colour strength (K/S value), using Spectrophotometer.
6) To assess the antimicrobial property the fabric subjected to natural dyes.
7) To conduct qualitative phytochemical analysis.

6. MATERIALS AND METHODS

Material used- Plain weave cotton fabric was used for the dyeing process. The cotton material was bleached and scoured prior to dyeing process to remove the possible impurities like dirt, or any other finishing agent present on the fabric and to aid in even absorption of the dye.

Method: The study was carried out in following steps

1) **Collection of Raw materials:** The tea dust (3 roses tea) after the extraction of tea (decoction) and the filter coffee (Cothas filter coffee) dust after the extraction of coffee (decoction) were collected. The extraction of both the beverages namely tea and coffee were done only with water and without adding milk. The tea and filter coffee dust after extraction were shade dried separately for three days.
2) **Pre- mordanting:** The cotton fabric was subjected to pre-mordanting using Alum (Potassium aluminum sulfate).
3) **Extraction of Dye:** The dye extraction was carried out in an aqueous medium (MLR 1:20 Time 1 hour)
    - **Tea:** To extract the dye, 100 grams of the dried tea dust was soaked in 2 litres of water and left for one hour. Then, the contents were boiled for half an hour to extract the colour from the tea dust. The extract was filtered using a cotton cloth and was used as the dye bath to colour the mordanted cotton fabric.
    - **Coffee:** To extract the dye, 100 grams of the dried coffee dust was soaked in 2 litres of water and left for one hour. Then, the contents were boiled for half an hour to extract the colour from the coffee dust. The

extract was filtered using a cotton cloth and was used as the dye bath to colour the mordanted cotton fabric.

4) **Dyeing process**: The pre-mordanted cotton fabric was introduced into the dye bath (tea and coffee dye bath separately) and was stirred gently. The contents were boiled for one hour at 90ºC with constant turning of the material. Then the dyed cotton fabric was rinsed three times in cold water and was dried in shade.

Table 1

Table 1 Dye Extraction and Fabric Dyeing

Extract Soaking

Fabric Dyeing

Washing & Rinsing

Source Pictures from author's kitchen Dyeing

5) **Colour fastness properties:** The dyed fabrics were subjected to colour fastness assessment such as light, crocking, washing, perspiration and pressing. The standard methods followed for the analysis of colour fastness is as follows

- Colourfastness to Light [IS:2454-1989 RA 2010] Assessment of colour changes with blue wool standards.
- Colourfastness to Crocking (Dry and Wet) [IS:766-1988 RA 2009] was evaluated using the crock meter.
- Colourfastness to Washing @ 40^0 C [ISO: 105 C-10:2006] was evaluated using a launder meter.
- Colourfastness to Perspiration [IS:971-1983 RA 2009]
- Colourfastness to Pressing (Dry, Damp and Wet) [IS:689-1956]

The colour change of dyed fabrics and the colour staining on the adjacent white fabric were assessed using greyscale standards. (Table 1)

Table 2

Table 2 Colour Fastness Assessment Parameters (Grey Scale Standards)

Grey Scale Rating	Colour Change	Staining
5	Excellent	Nil
4	Good	Slight
3	Fair	Noticeable
2	Poor	Considerable
1	Very poor	Extensive

6) **Assessment of colour strength:** The shades developed by the tea and coffee dyed fabrics were assessed using Spectrophotometer. Colour strength (K/S) of the dyed fabrics were determined (K- Absorption co-efficient, S- Scattering coefficient)

7) **Screening the natural dyed fabrics for antimicrobial activity:** Recently textile materials with antimicrobial properties have attracted interest of manufacturers and consumers as they remain fresh and odour free for daily use providing consumers with greater comfort. Yusuf et al. (2012).

   The antimicrobial test for textiles is AATCC TM 100 standard which is globally recognized. This is a quantitative method in which the assessment of antimicrobial finishes on textile materials, is determined by the degree of antimicrobial activity. This test uses a nutrient rich broth that allows aggressive growth of bacteria and reproduction Ristic et al. (2011).

8) **Phytochemical screening:** Phytochemicals are chemical compounds which are naturally present in the plants attributing to positive or negative health effects. They are the secondary metabolites which possess different health benefits and with respect to plants, they also own color, aroma, and flavor Silva et al. (2017). The medicinal properties of the plants are determined by the phytochemical constituents which shows various physiological effects on human body Stephen & Ejikeme (2016).

   The tea and coffee crude extracts were used to prepare the stock solution for the phytochemical analysis. The qualitative phytochemical screening was carried out using the following procedure Pradhan et al. (2011), Hossain et al. (2013).

   - **Test for Alkaloids:** The stock solution was treated with a few drops of Hager's reagent (saturated picric acid solution).

     The formation of yellow precipitate indicates the presence of alkaloids.
   - **Test for Saponins:** The stock solution was mixed with water and shaken.

     Formation of froth which was stable for a few minutes indicates the presence of Saponins.
   - **Test for glycosides:** 5 ml of the extract was treated with 2 ml glacial acetic acid and 1 ml of 5% ferric chloride. After heating gently, it was transferred to a test tube containing 2 ml of conc. H2SO4.
   - **The appearance of the reddish:** brown color at the junction of two liquids indicates the presence of glycosides Khatun & Mostafa (2021).
   - **Test for Proteins:** (Biuret Test) to 5 ml of extract was added a few drops of biuret's reagent. The obtained mixture was shaken well and was warmed for 1-5 min.

     Appearance of red or violet colour indicated presence of proteins Panchal & Parvez (2019).
   - **Test for Phenols** 5 ml of stock solution was taken to which 3ml of 10% lead acetate were added.

     A thick white precipitate indicated the presence of phenol compounds.
   - **Test for Terpenoids:** 2.0 ml of chloroform was added to the 5 ml aqueous plant extract and evaporated on the water path and then boiled with 3 ml of concentrated H2SO4.

     A grey color formed shows the presence of terpenoids.
   - **Test for Carbohydrates:** Fehling's test-5 ml of the extract was mixed with few drops of benedict's reagent and boiled.

     The reddish-brown precipitate formed indicates the presence of carbohydrates.

- **Test for Amino acids (Xanthoproteic test):** 2 ml of the stock solution Few drops of 0.2% of Nitric acid was added.

  A yellow-coloured solution indicates the presence of Amino acids Shaikh & Patil (2020).

7. RESULTS AND DISCUSSION

Extraction of dyes: The dyes were extracted from the residues after tea and coffee extraction using the aqueous extraction method which can be easily adopted at home.

Application of extracted dyes to cotton fabric: The extracted dyes were applied to cotton fabric which was mordanted using a safe and easily available mordant alum. The tea and coffee dyed samples showed shades of brown colour. (Table 3)

Table 3

Table 3 Cotton Fabric Subjected to Mordanting and Dyeing

Bleached and Scoured Fabric	Mordanted Fabric	Tea Dyed Fabric	Coffee Dyed Fabric

Source Pictures from author's kitchen Dyeing

Tea (Camellia sinensis) extract dyed cotton fabric produced an elegant pale to golden orangish colour while the coffee dyed cotton fabric produced an golden yellowish colour with good wash fastness properties.

Evaluation of Colour fastness: Colour fastness of dyed samples, with tea and coffee extract, was rated qualitatively. Change in colour and staining was assessed using Standardized grey scale. (Table 4)

Table 4

Table 4 Colour Fastness Assessment - Tea and Coffee Dyed Samples

Colour		Tea	Coffee
Light		3	2-3
Crocking	Dry	4-5	4-5
	Wet	3-4	4
Washing	Colour Change	3	2
	Staining on Acetate	4-5	4-5
	Cotton	4-5	4-5
	Nylon	4-5	4-5
	Polyester	4-5	4-5
	Acrylic	4-5	4-5
	Wool	4-5	4-5
Perspiration	Colour change – Acidic	4	4
	- Alkaline	3	4

	Staining on Acetate-Acidic	4-5	4-5
	Acetate-Alkaline	4-5	4-5
	Cotton-Acidic	4	4
	Cotton-Alkaline	4-5	4-5
	Nylon-Acidic	4	4-5
	Nylon-Alkaline	4-5	4-5
	Polyester-Acidic	4-5	4-5
	Polyester-Alkaline	4-5	4-5
	Acrylic-Acidic	4-5	4-5
	Acrylic-Alkaline	4-5	4-5
	Wool-Acidic	4-5	4-5
	Wool-Alkaline	4-5	4-5
Pressing	**Dry**		
	Colour change	4-5	4-5
	Staining on Cotton	5	5
	Damp		
	Colour change	4-5	4-5
	Staining on Cotton	4-5	4-5
	Wet		
	Colour change	4-5	4-5
	Staining on Cotton	4-5	4-5

From Table 4, it can be inferred that

- The dyed samples were assessed for Light fastness using the blue wool samples. Both the samples dyed with Tea and coffee extracts showed reading of 3 and 2-3, exhibiting fair light fastness.
- The tea and coffee dyed samples showed very good to excellent dry crock fastness in comparison with wet crock fastness which was rated very good.
- The tea and coffee dyed sample showed good wash fastness rating. The colour staining on various fabrics while washing was also very light hence were rated between very good to excellent.
- The acidic and alkaline perspiration colourfastness tests carried out on the dyed samples showed very good results to colour change. The observation on the colour staining on various fabrics was also very light hence were rated between very good to excellent.
- The dry and wet pressing colourfastness results of both the samples shows very good to excellent colourfastness.

The overall results of the samples dyed from the residue of tea and coffee extracts showed good to excellent results to colour fastness to Washing, Rubbing, Perspiration and Pressing. While the colourfastness of the samples dyed with tea and coffee extracts to light showed fair fastness (Table 4 and Figure 1)

Figure 1

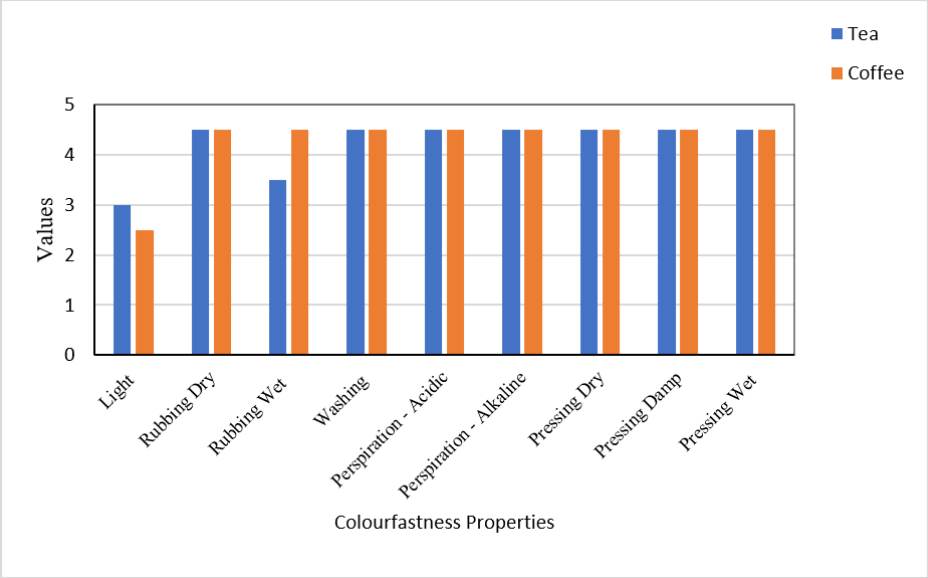

Figure 1 Colour Fastness Properties of the Tea and Coffee Dyed Samples

Assessment of colour strength of the dyed fabrics: The shade developed on the cotton fabric was assessed after dyeing the pre-mordanted fabric. The colour strength of the tea and coffee dyed fabric, K/S ratio, was measured using spectrophotometer. (K - Absorption co-efficient and S - the scattering coefficient). The spectrophotometer values are presented in Table 5.

Table 5

Table 5 Depth of Shade

Dye	K/S
Tea	1.6
Coffee	0.4

It was found that the cotton fabric which was dyed using tea had higher K/S value than the coffee dyed fabric.

Assessment of the antimicrobial property of the fabric subjected to the natural dyes: The tea and coffee extract dyed samples were assessed for their antimicrobial properties.

Table 6

Table 6 Antimicrobial Activity Shown by Natural Dyed Samples

Organism	Fabric dyed with Tea Extract	Fabric dyed with Coffee Extract
Escherichia coli (**Gram-negative** bacteria)	++	++
Staphylococcus aureus (Gram-positive bacteria)	++	+

\+ : Turbidity at lower concentration

++ : Turbidity at medium concentration

+++ : Turbidity at higher concentration

In the present study, the natural dyed samples were screened for their anti-microbial activity against selected microbes. The samples were tested for two human pathogenic organisms Escherichia coli (gram negative) and Staphylococcus aureus (gram positive) bacteria. From the results shown in Table 6. it is evident that the tea extract and coffee extract dyed samples showed good antimicrobial activity against both bacteria. The dyed samples were able to control the growth of both the organism which was visibly vivid in the turbidity test. Hence both the dyes have very good antimicrobial properties.

In a study conducted by Hong (2018) the fabrics treated with spent coffee extract had superior antioxidant ability and showed antibacterial ability, particularly to Gram-positive bacteria. Hence it is evident from the study that there are opportunities for the use of the tea extract and coffee extract natural dyes for adding antimicrobial properties to clothing and textiles.

Phytochemical analysis of Tea and Coffee extracts: The tea and coffee extract dyed samples were subjected to the qualitative phytochemical analysis to identify the presence or absence of various components.

Table 7

Table 7 Phytochemical Analysis of Tea and Coffee Extracts

Phytochemical	Tea Extract	Coffee Extract
Alkaloids	+	+
Saponins	+	+
Glycosides	-	-
Proteins	+	+
Phenols	+	+
Terpenoids	-	-
Carbohydrates	+	+
Amino acids	-	-

The qualitative phytochemical analysis of the Tea and Coffee extracts confirmed the presence of various phytochemicals, like alkaloids, saponins, proteins, phenols, and carbohydrates. The result shows that terpenoids and aminoacids were absent.

8. CONCLUSION

Natural dyeing one of an ancient art form of colouring textiles can be revived in a sustainable manner. This study shows a simple dyeing process which can be carried out at home using available resources. It is an innovative upcycling approach towards kitchen waste management. Hence a small initiative can contribute to the revival of the art, protecting the environment and to promote sustainability. This study proves that wastes from kitchen could also be a potential source to extract colour which can be employed for textile coloration. It is evident from the study that the waste generated after extracting tea and filter coffee still contain significant amounts of functional ingredients. In addition, the extract obtained contains sufficient amounts of color to dye fabric and hence it can be effectively used to dye textiles and it gives unique shades. The colour fastness properties of these dyes were also very good. It is evident that these dyes also have good antimicrobial property. The Tea and Coffee dye extract contains various phytochemicals, like alkaloids, saponins, proteins, phenols, and carbohydrates. Since these dyes are natural in

origin, they are eco-friendly dyes suitable for green technology. Hence beverage waste generated from food industry which has the colouring pigments can be effectively utilized to colour textile materials hence producing value addition. It is an innovative, simple, and eco-friendly waste management solution in textile dyeing.

CONFLICT OF INTERESTS

None.

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