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Extraction and Application of Eco – Friendly Natural dye obtained from Leaves of *Acalypha indica Linn* on Cotton Fabric

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Abstract

The present investigation was carried out to revive the old art of dyeing with natural dye from leaves of Acalypha indica Linn. It belongs to family Euphorbiaceae, commonly known as kuppaimeni. The dye has good scope in the commercial dyeing of cotton in textile industry. In the present study, bleached cotton fabrics were dyed with different chemical and natural mordants. Dyeing was carried out by pre-mordanting, post mordanting and simultaneous mordanting. The dyed samples have shown good washing, light, rubbing fastness and perspiration fastness properties. The various colour changes were measured by computer colour matching software. ICPMS studies have proved that, heavy metals such as antimony, arsenic, cadmium and lead were not present in the dye extract. Anti-bacterial and anti-fungal activities of the dye were also studied.

Keywords: Extraction, natural dye, leaves, *Acalypha indica Linn*, cotton, textiles..

Introduction

Natural dyes are known for their use in colouring of food substrate, leather, wood as well as natural fibers like wool, silk, cotton and flax as major areas of application since ancient times. Natural dyes may have a wide range of shades, and can be obtained from various parts of plants including roots, bark, leaves, flowers, and fruit. Since the advent of widely available and cheaper synthetic dyes in 1856 having moderate to excellent colour fastness properties, the use of natural dyes having poor to moderate wash and light fastness has declined to a great extent. However, recently there has been revival of the growing interest on the application of natural dyes on natural fibers due to worldwide environmental consciousness[1]. The widely and commonly used synthetic dyes impart strong colour but causes carcinogenicity and inhibition of benthic photosynthesis[2]. In many of the world's developing countries, natural dyes can offer not only rich and varied source of dye stuff, but also the possibility of an income through sustainable harvest and sale of these plants[3].

The use of natural dyes for textile dyeing purposes, decreased to a large extent after the discovery of synthetic dyes in 1856. As a result, with a distinct lowering in synthetic dye stuff costs, the natural dyes were virtually unused at the beginning of twenties century[4]. Presently there is an excessive use of synthetic dyes, estimated at around $10x10^6$ tons per annum, the production and application of which release vast amount of waste and unfixed colorants causing serious health hazards and disturbing the eco-balance of nature. Nowadays, fortunately, there is increasing awareness among people towards natural dyes. Natural dyes are preferred in developed countries, because they are non-allergic, non-carcinogenic and have lower toxicity and better bio degradability than the synthetic dyes[5].

Acalypha indica Linn is a species of plant having catkin type of inflorescence. It is a common herb growing up to 75 cm tall with ovate leaves. Flowers are green, unisexual found in catkin inflorescence. In West Africa the leaves are cooked and eaten as a vegetable. It is also browsed by cattle. This plant is held in high esteem in traditional Tamil siddha medicine as it is believed to rejuvenate the body. The common a names of *Acalypha indica* are Indian acalypha, Indian nettle (English), Ricinelledes Indes, oreilledechatte, herbechatte (French), Poonamayakki and Kuppaimeni (Tamil). It is use as a purgative for which purpose the plant is boiled and the extract drunk. It is a very good remedy in the treatment of piles. Root is used to remove worms in children, and given in the morning empty stomach work as mild laxative and also remove worms. The leaves with turmeric for relief from acne and pimples. The root is prescribed as a tonic, astringent, febrifuge and strong purgative. Extract of the root bark with alcohol can be used for back wart fever. The leaves are laxative and used externally as emollient, a poultice is used for chilblains, in insect bites, swelling, rheumatism and facial paralysis. Leaves possess anti-periodic and laxative properties, the leaves are used in jaundice, piles, rheumatism ulcers and also externally skin eruptions, ring worms, eczema. The leaves extract are applied to pustules, insect bites[6].

Material and Methods

Source: The leaves of *Acalypha indica Linn* was collected from Mariyamman kovil village, Thanjavur district as shown in figure–1 and figure–2.

Figure-1
***Acalypha indica Linn* Plant**

Figure-2
Leaves of *Acalypha indica Linn*

Substrates: Desized, scoured and bleached cotton fabric was used for dyeing.

Chemicals used: AR grade metallic salts such as copper sulphate, ferrous sulphate, alum [$(K_2SO_4.Al_2(SO_4).24H_2O$], potassium dichromate, nickel sulphate and stannous chloride were used as chemical mordants. Myrobolan and cow dung were used as natural mordants.

Dye extraction: Leaves of plant were soaked with 70% ethanol and heated in a beaker kept over a water bath for 2 hours to facilitate quick extraction. Then it was filtered and the filtrate was collected in a separate beaker.

Dyeing procedure: The cotton samples were dyed with dye extract keeping different M: L ratio such 1:10, 1:20 and 1:30. Dyeing was carried out different temperatures such as 40°C, 60°C and 80°C and continued for 1 hour.

Mordanting: The cotton fabrics were treated with different chemical and natural mordants by following three methods[7].

Pre-mordanting (PM): In this method, cotton fabrics were pretreated with the solution of different chemical and natural mordants and then dyed with dye extract.

Post mordanting (POM): In this method, dyed cotton fabrics were treated with solution of different chemical and natural mordants.

Simultaneous mordanting (SM): In this method, the cotton fabrics were dyed with dye extract as well as different chemical and natural mordants.

Colour fastness: The colour fastness of the dyed fabrics was tested according to IS standards. Colour fastness to washing, light and rubbing were determined from standard test methods IS-687-79, IS-2454-85 and IS-766-88 respectively[8].

Measurement of colour strength: The colour strength of the dyed cotton fabrics were determined by K/S values. The light reflectances of the dyed cotton samples were measured using a Text flash spectrophotometer (Data colour corp.). The K/S values were calculated by Kubelka-Munk equation.

$$K / S = (1 - R)^2 / 2R$$

Where, R is the decimal fraction of the light reflectance of the dyed fabrics at λ_{max}. K is the absorption coefficient and S is scattering coefficient[9].

ICPMS studies: The presence of heavy metals like antimony, arsenic, cadmium and lead in dye causes dermatological problems to the wearer and also eco-friendly dye should not contain these heavy metals[10]. The presence / absence of these heavy metals were tested by Inductive Coupled Plasma Mass Spectrometer (ICPMS).

Antibacterial and antifungal activity studies: Textile materials and garment are susceptible to microbial attack, as these provide large surface area and absorb moisture required for microbial growth. This often results in objectionable odour dermal infection, product deterioration allergic responses and often related diseases[11].

Antibacterial activity: For the purpose of antibacterial evaluation, five bacterial pathogens were used[12]. *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiellapneumonia*, *Staphylococcus aureus* and *Enterobactorsp* were employed for determination of antibacterial activity of the dye.

Antifungal activity: For the purpose of antifungal evaluation, five fungal pathogens were used[12]. *Aspergillusniger, Candida*

albicans, Candida kefyr, Candida tropicalis and *A. flavus*were employed for determination of antifungal activity of the dye.

Result and Discussion

Preparation and optimization of ethanolic extract of *Acalypha indica Linn*: The leaves of *Acalypha indica Linn* were found to discharge colour in 70% ethanol very easily. Increasing the quantity of leaves 5 g to 20 g per 100 mL ethanol boiled for 30 minutes is accompanied with the increase in colour strength and depth in colour[13]. It was observed that, colour of the dye extract was dark greenish yellow colour.

Effect of mordanting: The dye extract was found to be suitable for cotton fabric. The cotton fabrics were dyed with chemical and natural mordants. It was observed that, the dye uptake was found to be good in post mordanting (POM) method is shown in figure-3.

Effect of M:L ratio: The cotton samples were dyed with dye extract keeping various M:L ratio as 1:10, 1:20, 1:30 and 1:40. It was observed that the dye uptake was good in M:L ratio 1:30.

Effect of temperature: The effect of temperature on the dyeability of cotton fabric with dye extract was conducted at temperatures like 40°C, 60°C and 80°C. It was clear that the colour strength (K/S) values increased with increase of dyeing temperature.

Optimization of mordants with K/S value and colour hue changes: Various hues of colour were obtained from post mordanted cotton with potassium dichromate, ferrous sulphate, alum [$(K_2SO_4.Al_2(SO_4).12H_2O$], copper sulphate, nickel sulphate, stannous chloride, myrobolan and cow dung as shown in table-1. The different mordants not only cause difference in hues of colour and significant changes in K/S values but also changes in L* values and brightness index value. The effect of mordants on colour values of cotton dyed with leaves of *Acalypha indica Linn* is shown in figure-4.

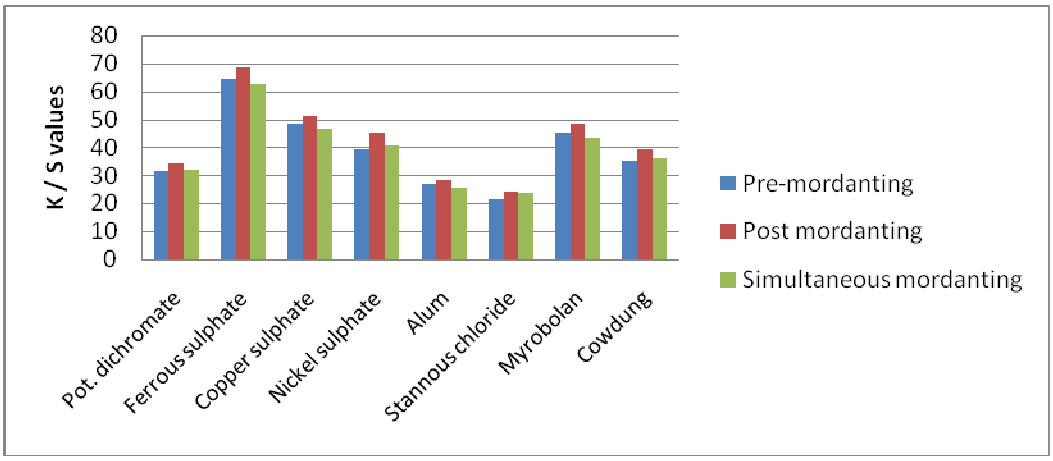

Figure-3
Surface colour strength (K/S values) of dyed cotton fabrics after pre, post and simultaneous mordanting

Table-1
Colour produced on cotton by different mordants in post mordanting (POM)

Mordants	Colour obtained	Mordants	Colour obtained
Potassium dichromate		Alum	
Ferrous sulphate		Stannous chloride	
Copper sulphate		Myrobolan	
Nickel sulphate		Cow dung	

Table-2 shows L*, a*b*and K/S values and it can be seen that, mordants which show higher value of L* show lighter shades while lower L* value show darker shades for cotton. Similarly, negative values of a* and b* represent green and blue respectively. Among the chemical mordants used, the highest colour value (K/S = 68.39) was obtained with ferrous sulphate and lowest colour value (K/S = 24.01) with nickel sulphate. Natural mordant like myrobolan showed the higher colour value (K/S = 48.32) than the cow dung (K/S = 39.12).

Fastness properties: It was observed that, dyeing with *Acalypha indica Linn* gave good fastness properties. The fastness properties of dyed cotton fabrics are shown in table-3. Overall, it could be used for commercial purposes and attain acceptable range.

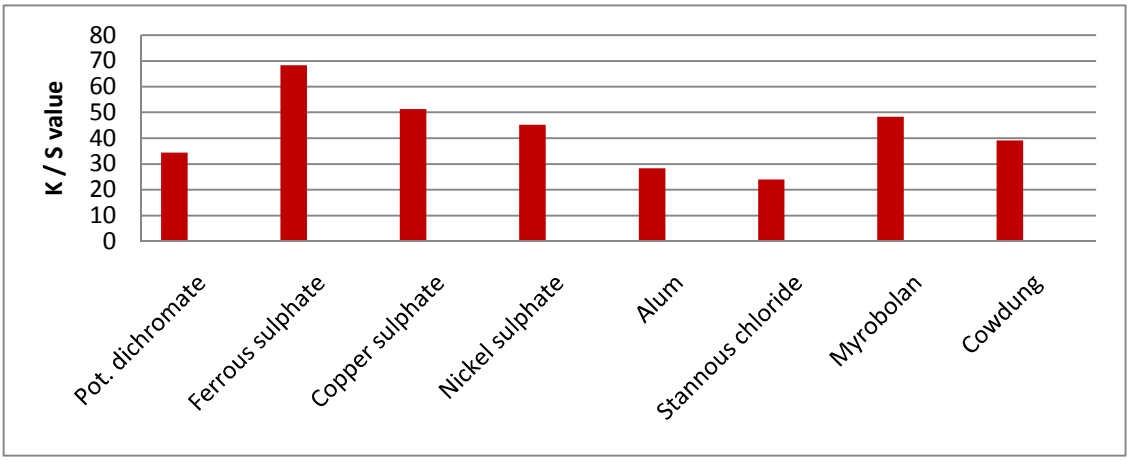

Figure-4
Effect of post mordants on colour values of dyed cotton fabrics

Table-2
Different post mordants, L*, a*, b* and K/S values for cotton dyed with leaves of *Acalypha indica Linn*.

S.No.	Mordants	L*	a*	b*	K /S value
1	Potassium dichromate	64.42	1.570	1.99	34.39
2	Ferrous sulphate	52.80	0.578	7.38	68.39
3	Copper sulphate	58.74	1.967	11.58	51.25
4	Nickel sulphate	67.78	1.867	10.54	45.25
5	Alum	76.66	0.603	14.51	28.33
6	Stannous chloride	78.54	0.675	15.22	24.01
7	Myrobolan	63.78	1.745	10.68	48.32
8	Cow dung	57.54	1.854	9.64	39.12

Table-3
Fastness properties for cotton fabric dyed with leaves extract of *Acalypha indica Linn.*

S. No.	Mordants	Washing (IS-687-79)	Light (IS-2454-85)	Rubbing (IS-971-83)	
				Dry	Wet
1	Potassium dichromate	4 – 5	IV	3 – 4	4
2	Ferrous sulphate	4 – 5	V	4 – 5	4 – 5
3	Copper sulphate	4 – 4/5	V	3 – 4/5	3 – 4
4	Nickel sulphate	3 – 4/5	IV	4	3 – 4
5	Alum	3 – 4	IV	4 – 5	3 – 4
6	Stannous chloride	3 – 4	IV	4	3 – 4
7	Myrobolan	4 – 5	IV	4	4
8	Cow dung	3 – 4	III	3 – 4	3 – 4

ICP-MS studies: Inductive Coupled Plasma Mass Spectrometer (ICPMS) studies have proved that, heavy metals such as antimony, arsenic, cadmium and lead were not present in the dye obtained from leaves of *Acalypha indica Linn* and will not cause any skin problems to the wearer.

Anti-Bacterial and anti-fungal activity Studies: In this study, five different bacterial and fungal pathogens were used to screen the possible antimicrobial activity of dye extract. Dye extract exhibited antibacterial and antifungal activity against all tested microorganisms.

Antibacterial activity: The dye extract showed good antibacterial activity against the five bacterial pathogens. Among the five bacterial pathogens, dye extract showed more effective against *Staphylococcus aureus* and *Escherichia coli* pathogens as shown in table-4.

Table-4
Antibacterial activities of dye extract from leaves of *Acalypha indica Linn*.

S.No.	Name of bacterial pathogens	Zone of inhibition (mm)
1.	Escherichia coli	11.0±0.20
2.	Pseudomonas aeruginosa,	9.97±0.6
3.	Klebsiellapneumonia.	*7.90*±0.10
4.	Staphylococcus aureus	13.83±0.29
5.	Enterobactorsp	7.35±0.3

A**nti-fungal activity:** The dye extract showed good antifungal activity against the five fungal pathogens. Among the five fungal pathogens, dye extract showed more effective against *Candida albicans* and *Aspergillusniger* pathogens as shown in table-5.

Table-5
Antifungal activities of dye extract from leaves of *Acalypha indica Linn*

S.No.	Name of fungal pathogens	Zone of Inhibition (mm)
1.	Aspergillusniger	9.97±0.10
2.	Candida albicans	13.93±0.12
3.	Candida kefyr	8.07±0.12
4.	Candida tropicalis	9.07±0.12
5.	A.flavus	6.14±0.6

Conclusion

The present work shows that, leaves of *Acalypha indica Linn* can be used as dye for colouring textiles. These are grown throughout India and it is easily available plant. Different shades of colour can be obtained using different chemical and natural mordants. The washing, light and rubbing fastness of all dyeing with mordants were quite good and also dye extract has shown good antibacterial antifungal activity. The dye has good scope in the commercial dyeing of cotton.

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