

# An Eco-Friendly Natural Dyeing On Wool and Cotton Fabric by Medicinal Herbs Azadirachta Indica and Ocimum Tenuiflorum

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## ABSTRACT

Since ancient times human beings have been using herbs and plants for curing various ailments and diseases due to their medicinal values and easy availability in nature. Later with advancement in technology these herbs got major importance in pharmaceutical industry due to their suitable chemical composition, abundant availability and easy access, Azadirachta indica and ocimum tenuiflorum herbs are also well mentioned in ayurveda with vast application areas for Medicinal purposes. But no or very less literature has been found regarding their colouring behaviour and antimicrobial activity. Present research is an attempt to explore colouring behavior and antimicrobial activity of these two herbs on wool. Mordanting of the fabric was carried out using three mordanting technique i.e. pre, meta and post-mordanting using natural as well as chemical mordants i.e. Alum, Aavla powder. Dyed samples were further analyzed for colour strength, colour fastness properties and antibacterial testing. Both herbs give a wide colour spectrum in yellow-green or yellow-red region with excellent fastness properties. The overall results show that both of these dyes can be successfully used and explored further for dyeing of wool with medicinal properties.

**Keywords:** Azadirachta Indica, Ocimum Tenuiflorum, Natural dye, Mordant, L\*, a\*, b\* values, Colour fastness, Antimicrobial activity.

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## INTRODUCTION

Natural dyes are sustainable being renewable. Although natural dyeing using chemical mordants generates a large amount of effluents in terms of carcinogenic heavy metals. Therefore, there is dire need to find out suitable eco-friendly mordants for natural dyes. The use of abundantly available waste of vegetables, fruits and other natural resources such as orange peel extract, pomegranate peel extract, natural herbs, etc as natural dyeing and mordanting agents can be better substitutes to synthetic substances [2]. Some available natural substances can be used as a natural dyeing agent as well as mordants. Gooseberry powder and harda are this type of natural substances which acts as dye as well as mordanting agent providing excellent gamut of shade [3]. Mordanting can be carried out by pre, simultaneous and post mordanting techniques. Different types of mordants give different shade spectrum according to application whether applied individually or in combinations [4, 5]. Natural dyeing of different textiles and leathers has been continued mainly in the decentralized sector for specialty products along with the use of synthetic dyes in the large scale sector for general textile /apparels owing to the specific advantages and limitations of both natural dyes and synthetic dyes [6].

Present study aim to study dyeing of wool and silk with natural dye extracted from the Tusli and Neem using Alum and Amla powder as mordants. A mordant is a substance used to fix dyes in the interior of fabrics by forming a coordination complex or covalent bond with the dye which then attaches to the fabric or tissue. In first part of the study dyes were extracted from Neem and Tulsi and then further these Extracted dyes were applied on on cotton and wool fabrics by the use of mordants. The use of mordants produces various colour shades with tusli and neem dyes. These colour shades were obtained from various mordanting techniques ie. pre, post and simultaneous mordanting.. After dyeing, the fastness properties such as light, rubbing, and washing fastness were tested for all the dyed samples. s. Staining and change in colour during wash fastness testing were assessed by using standard grey scale.

Many of the plants used for dye extraction are classified as medicinal and some of these have recently been shown to possess remarkable antimicrobial activity. *Punica granatum* and many other commonly available natural dyes are reported as potential antimicrobial agent owing to the presence of a large amount of tannins. Natural dyes rich in naphthoquinones such as lawsone from henna, juglone from walnut and lapachol from alkanet are reported to exhibit antibacterial and antifungal activity. However dyes commonly used in textile are seldom screened for use as antimicrobial agent for textile finishing.

### Objectives

- To study the dyeing ability and antimicrobial activity of two different kind of medicinal herbs *azadirachta indica* and *ocimum tenuiflorum*.
- To investigate the effect of the mordant, pH and affinity for fibre types alongwith shade and colour development.
- To optimise dyeing condition in term of dye and mordant concentration, pH range, temperature, time and MLR (material to liquor ratio).
- To conduct experiments for evaluation of dyed fabric, including the colour fastness to washing, colour fastness to light, rubbing fastness in term of dry and wet state along with computer colour matching or colour strength.[7]
- To use the regenerated resources as the dyeing agent and to produce eco-friendly dyed fabric.
- To study the experimental data of dyed samples and express them by means of graphs and curves.

### Significance of study

The chemical dyes have been largely used extensively all over the world, due to their cost effectiveness, fastness properties and brilliancy of shade. Although the demand for natural dyed garments or products are also increasing due to sustainability issues. This means that the development of natural dye is an important issue making it becomes more user friendly for the dyeing industry or small dyeing house. The use of different mordants and mordanting technique can help to produce variety of shades with unlimited colours. Some substantive dyes can provide a strong colour to fabric even without using mordant. Overall natural dyes are attracting the world-wide attention again.

The study seeks to explore and capture some natural plants from which dyes can be extracted and applied to selected textile fabrics. The study also plays a distinctive role in providing beneficial information to the textile, food and medical industries as well as art lecturers, students and scholars. In addition, the study would create the awareness of unexplored indigenous plant dyes and finally serve as a reference material to other research works. [8]

## LITERATURE REVIEW

This Paper aims to provide a comprehensive review of the past study performed on herbs *Azadirachta indica* and *Ocimum tenuiflorum*. It is well known that these herbs consist various medicinal properties to cure different kind of disease in pharmaceuticals industries and can be used as natural dyes in textile. Therefore all the relevant literature found on ***Azadirachta indica*** and ***Ocimum tenuiflorum*** has been discussed in following section.

### ***Azadirachta indica* (Neem)**

*Azadirachta indica* (Neem) is a tree in the mahogany family Meliaceae as shown in Fig 1. It is one of two species in the genus *Azadirachta* and is native to the Indian subcontinent, i.e. India, Nepal, Pakistan, Bangladesh and Sri Lanka. It is typically grown in tropical and semi-tropical regions. Neem trees now also grow in islands located in the southern part of Iran. Its fruits and seeds are the source of neem oil. [9]



**Fig.1: Tree of Azadirachta indica (Neem)**

**Ocimum tenuiflorum (Tulsi)**

Ocimum tenuiflorum (Tulsi ) or Holy basil is a sacred plant in Hindu belief as shown in Fig 2.. Hindus regard it as an earthly manifestation of the goddess Tulsi; she is regarded as a great worshipper of the god Vishnu due to its medicinal values. The offering of its leaves is mandatory in ritualistic worship of Vishnu. Many Hindus have tulsi plants growing in front of or near their home, often in special pots or a special masonry structure known as Tulsi Vrindavan. Traditionally, Tulsi is planted in the center of the central courtyard of Hindu houses. The plant is cultivated for religious and medicinal purposes and for its essential oil [10].



**Fig.2: Ocimum tenuiflorema (tulsi) plant**

**Extraction method of natural dyes**

The extraction of natural dyes from plants, animals and minerals is depend on various factors such as type of medium used (i.e. aqueous or some other solvent), pH of medium, condition of extraction such as temperature, time, material to liquor ratio and size of substrate [11].

- 1) Aqueous extraction: The respective plants' parts are taken and poured in boiling water and then kept on water bath at optimum temperature and optimum time duration so as to extract the entire colour from them.
- 2) Extraction by organic solvents: In this method organic solvents are used to extract the colour pigments from the respective plants' parts. Example of organic solvents which is used for natural dye extraction such as: methanol, ethanol, acetone, etc.
- 3) Extraction by acid and alkali: The extraction of natural dye from the respective plants parts are done under acidic and alkaline condition by using suitable acid i.e. HCl for acidic pH or suitable alkali i.e. sodium carbonate for alkaline pH [12].

**Natural mordants are used in dyeing of wool**

Wool fabric dyeing with turmeric by using natural mordants as the fresh petaloids banana flower dried under shade and crushed into powder form.

When a wool fabric is immersed in the dye bath solution then it gets wetted and swells due to weakening the ionic linkage. The dissociation of  $-COOH$  and ammonium groups take place. The net charge on wool becomes zero. As the dyeing process is go on the pH of dye bath increases due to breaking of H- bonds which is combine with ionized carboxylic groups of aspartic and glutamic acid residues and hence the formation of unionized aspartic and glutamic acid residue remain ionized, resulting in increase in positive charge on wool [13]. These positive charge ( $-NH_3^+$ ) serves as attraction forces for colouruants having negative charges ( $-OH$ ). When natural mordants is added in the dye bath solution then its molecules migrates from dye bath solution, get adsorbed on the surface of the fibre and diffuse into the interior of the dyed fibre.

Natural mordant serve as a protective layer through its binding sites which acts as a cover for both the wool protein and turmeric colouruant. With the increase in the percentage of natural mordant in dyeing process, the binding forces of natural mordant become strong due to the increase in number of available binding sites and this improves light and wash fastness

properties and increase concentration of natural mordant does not cause any damage to wool. [14].

**MATERIAL AND METHOD**

**1) Herbs collection:** - azadirachta indica and ocimum tenuiflorum herbs as shown in Fig.3 were collected from campus of Bhagat Phool Singh Mahila University, Sonapat, Haryana.

**2) Wool fabric:** - 100% wool fabric was procured from local market of Rohtak.

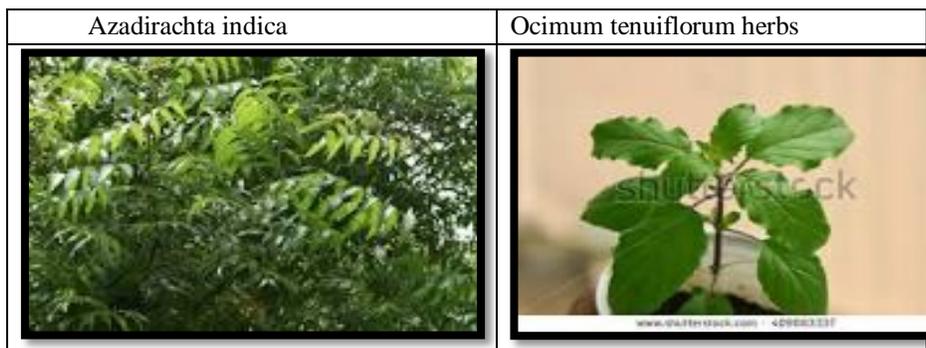
Weight= 2.75g

EPI= 54

PPI= 58

Cotton Fabric:

**3) Mordants:** - Alum and Aawla power as shown in Fig. 3 was procured/collected from local market/area.



**Fig. 3: Raw materials (herbs ) for dyeing**

**Optimization of dyeing condition**

Dyeing and mordanting condition were optimised by taking various variants as shown in Table 1. To optimization of one variant other variants were kept constant during the dyeing. Further based on dyeing results optimization was carried out. [15].

**Table 1: Various variants in optimization of dyeing recepie and concentration of natural mordants**

Natural mordant	Dye Cons.	Mordant Conc., gpl	Time, Min	Temp, °C	pH	M:L:R
Aavla powder and aluminium sulphate	20% owf	3	60	60	4-5	1:10
	22% owf	5	80	70	7	1:20
	24% owf	7	100	80	8-9	1:30

On the basis of preliminary observations Optimized dye, mordanting, time , pH, temp, and M.L.R condition are as follow:-

- Azadirachta indica - 22% owf
- Ocimum tenuiflorum - 22% owf
- Natural Mordant Concentration- 7 gpl
- Chemical Mordant Concentration- 7 gpl
- Time - 60 min
- Temp- 90°C
- pH- 4-5 (wool)
- pH- 8-9 (cotton )
- M: L: R - 1:30

**Methods of mordanting:**

**1) Pre - mordanting:** - in this method the fabric was first treated with mordant and then dyed under optimised conditions.

2) **Simultaneous –mordanting:** - in this method the fabric was dyed and mordanted at a same time under optimised conditions.

3) **Post - mordanting:** - in case of post mordanting the fabric was first dyed under optimised conditions and then treated with mordant.

All the three mordanting method were followed in dyeing experiments[16]

### Dyeing machine used

Dyeing was performed in borosil conical flask on water shaker bath machine as shown in Figure 4 at constant speed of 65 rpm speed.



Fig. 4: Water shaker bath machine

### Wash fastness test

- The wash fastness rating shows change or fading in colour as well as staining of adjacent fabric when subjected to washing.
- **Wash fastness tester:** - Wash fastness tester is used for determining colour fastness of textile material to washing as shown in Figure 5.
- **Washing procedure:** - a 10 x 4 cm swatch of the coloured fabric was taken and is sand witted between two adjacent fabrics preferably one side cotton and other side wool and stitched, the sample and the adjacent fabric are washed together as per AATCC 61 test standard. [17].

M: L: R	-	1:30
Specimen size	-	10 x 4 cm
Washing severity	-	mild washing
Detergent	-	5 gpl
Time	-	30 min
Temp	-	40 °C
Still ball	-	no
Grey scale	-	for assessing change of colour

After soaping treatment, specimen, was rinsed twice in cold water and then in running cold water under a tap. Further samples were queezed it and air dried at a temperture not exceeding 60°C. The change in colour and staining was evaluated from Rating 1 to 5 with the help of grey scales as per AATCC 61 test standard. [18] Rating 5 shows excellent wash fastness where as 1 show worse wash fastness



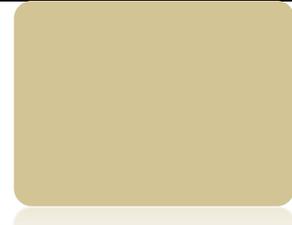
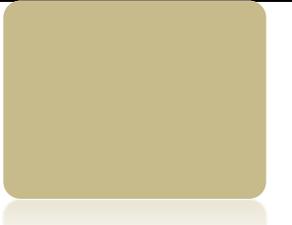
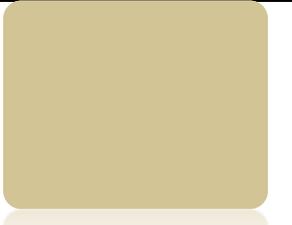
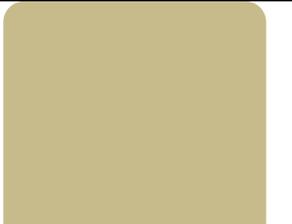
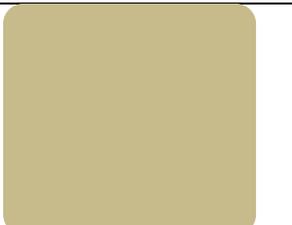
Fig. 5: Wash fastness machine

### RESULT AND DISCUSSION

- 1) In the present research study wool fabric was dyed as well as antimicrobial testing using two different kind of medicinal herbs - azadirachta indica and ocimum tenuiflorum, both herbs were used separately following pre, meta and post mordanting method .
- 2) Natural and chemical mordants were used for improving fastness properties and variations in shades. (Natural mordants- Aavla power) (Chemical mordants-Alum)
- 3) Aqueous extraction method was followed for extraction.
- 4) Dyeing is performed on water shaker bath at 65 rpm speed.
- 5) Dyeing receipe and condition were optimized before final dyeing [19].
- 6) Extracted dye of azadirachta and ocium in ethonal and in aqueous solution were tested for their antibacterial properties by Mueller –hinton agar method .

#### Result of azadirachta indica dyeing on wool and Cotton fabric

1) Dyed wool fabrics with azadirachta indica via pre, meta and post-mordanting methods are show in Fig.6.

Dye and Type of mordant	Pre-mordanting	Meta-mordanting	Post- mordanting
Aqueous extracted dye and Without mordant			
Ethanol extracted dye and Aavla powder			
Aqueous extracted dye and Aavla powder			
Ethanol extracted dye and Alum			



**Fig.6: Sample of cotton dyed fabric with azadirachta india**

**Colour values and Colour fastness of dyed cotton/woollen fabric with azadirachta indica**

Evaluation of colour fastness to washing and rubbing was ratted from 1 to 5. Rating 1 shows very poor wash and rubbing fastness where as maximum rating 5 shows excellent wash and rubbing fastness. Results of colour values in term of  $L^*$   $a^*$   $b^*$  and k/s, for azadirachta indica (neem herb) are tabulated in Table. 2 [20]

**Table 2: L, a, b and K/S values of dyed woollen and cotton fabrics with azadirachta indica (Neem Leaves)**

Fabric name	Mordant	Mordan-ting method	Colour coordinates				
			L	a	B	k/s	
Cotton	Without mordant	-----	80.338	-1.312	23.013	2.972	
	Alum	Pre	80.406	-1.089	19.689	2.733	
		Meta	76.673	-1.42	23.826	4.539	
		Post	82.126	-1.398	25.198	3.209	
	Aawla powder	Pre	85.508	-0.874	23.101	3.254	
		Meta	76.787	-1.204	28.315	3.279	
		Post	83.216	-0.138	23.751	1.17	
	Wool	Without mordant	-----	75.582	-0.425	11.137	11.917
		Alum	Pre	80.507	-3.134	16.140	8.843
Meta			78.355	-1.111	10.902	6.320	
Post			81.625	-2.695	18.666	11.069	
Aawla powder		Pre	79.698	-1.403	15.362	26.693	
		Meta	80.349	-1.776	17.502	27.840	
		Post	79.909	-0.612	15.678	23.289	

It can be observed from  $L^*$   $a^*$  and  $b^*$  values that azadirachta indica (neem herb) extracted natural dyed wool and cotton fabrics with alum mordant is in the yellowish colour range being significant high value of  $b^*$ . All the dyed samples of neem with alum in pre, post, meta mordarting method give yellow shade with slight greenish tinge being negative  $a^*$  values. Same trend is followed in azadirachta indica (neem herb) extracted natural dyed wool fabric with Aawla powder colour still lies in the yellowish colour range being significant high value of  $b^*$ . All the dyed samples of neem with Aala in pre, post, meta mordarting method give yellow shade with slight greenish tinge being negative  $a^*$  values.

**Colour values and Colour fastness of dyed cotton/woollen fabric with ethonal extracted azadirachta indica dye**

**Evaluation of colour fastness** to washing and rubbing was ratted from 1to 3. Rating 1 showes very poor wash and rubbing fastness where as maximum rating is 3 showes excellent wash and rubbing fastness.

**Table 3: colour values of dyed woollen and cotton fabrics with Tulsi leaves**

Fabric	Mordant	Mordan-ting method	Colour coordinates			
			L	A	B	k/s
Cotton	Without mordant	-----	78.359	-1.265	21.013	1.972
	Alum	Pre	79.639	-1.362	24.013	3.548
		Meta	76.673	-1.344	23.826	4.539
		Post	82.216	-1.398	25.198	3.209

	Aawla powder	Pre	85.508	-0.874	23.424	2.972
		Meta	78.479	0.064	22.234	1.302
		Post	83.216	-0.831	23.751	1.170
Wool	Without mordant	-----	71.44	-1.769	12.135	0.487
	Alum	Pre	67.929	-0.242	16.153	0.683
		Meta	63.299	-2.668	19.883	0.876
		Post	66.799	-1.24	12.6	0.519
	Aawla powder	Pre	71.169	-2.345	20.16	1.205
		Meta	76.948	-1.745	22.092	1.141
		Post	74.463	-1.411	15.519	0.684

It can be observed from table that L\* a\* and b\* values of tulsi extracted natural dyed cotton and wool fabrics with Aawla powder mordant is in the yellowish colour range being significant high values of a\*. All the dyed samples of neem with alum in pre, post, meta mordanting method give yellow shade with slight reddish being negative b\* colour value.

### CONCLUSION

It can be concluded from the study that azadirachta indica and ocimum tenuiflorum herbs both herbs also act as good dyeing agents for woollen textiles with a wide range of spectrum in yellow green/red region. Both the dyed samples with natural as well as chemical mordants give moderate to excellent fastness properties. So whole dyeing process can be carried out in an eco-friendly manner using natural dyes as well as natural mordant (Aawala) or chemical mordant (Alum). The renewable natural dyes with eco-friendly mordants i.e. natural mordants have good potential in sustainable textile wet processing with satisfactory antibacterial results.

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