



Utilization Of Ficus Benghalensis As A Natural Dye For Wool Fibres

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1. Abstract:

The paper focuses on the development of eco-friendly toys. Where the world is soaked up in artificial synthetic dyes that can be found on garments, gourmets, toys. In today's scenario there are a plethora of methods for colouring where synthetic dyes are employed mostly. But Parents nowadays are more specific on what their toddlers are exposed to when it comes to hazardous PVC toys in the market. The concern starts with the material and dye stuff of the product that has been manufactured. In this paper, the natural dyes are extracted from Ficus benghalensis. L that are applied to 100% merino wool with tamarind seed coat and cow chip as mordants. At first the dye extract was extracted from Ficus benghalensis by aqueous extraction. A beautiful beige hue was derived from the extract. The dyed woolen yarn was tested for antimicrobial activity, color fastness to sunlight, washing and rubbing, phytochemical screening, and FT-IR analysis. The study focuses on the development of 100% sustainable natural soft toys for toddlers to teenagers when compared to synthetic dyed soft toys or PVC toys.

Index Terms:

Crochet, Ficus benghalensis, Merino wool, Natural dye, Plastic toy, Sustainability, Synthetic dye, Toxic.

2. Introduction

Plastics is one of toxic substances that are hazardous environmental dump as they do not decompose within 1000 years (Ramesh and Devi, no date). Nearly 80% of all toys end up in landfills, incinerators or the ocean and account for almost 6% of landfill plastics. Plastic toys are difficult to recycle because of their complex form and chemical additives. To replace such hazardous products Parent nowadays are more specific on what their toddlers are exposed to when it comes to PVC toys in market. The need for sustainable toys is in demand whereas crochet an ancient sustainable yarn craft that requires minimal equipment such as yarn, a hook and creativity to design a sustainable products like soft toys for toddlers, teens whereas a decor product for home (Govil *et al.*, no date).

Wool is one of the most important natural fibres and is used extensively in textile industry along with synthetic fibres (Kadam *et al.*, 2024). This fibre has great characteristics such as good water and dye absorbency thus has wide application of natural dyes on wool yarn. Woolen yarns of high quality are used in crocheting to develop products like toys, keychain, flowers and many more (Wiedemann *et al.*, 2021). The natural elasticity of wool helps the stitches bounce back and retain their structure from defaming (Midolo *et al.*, 2025). The application of natural dyes has significantly increased as a result of growing research into the textile industry's adverse impacts on the environment (Mia *et al.*, 2022). These dyes are often praised for being less poisonous, biodegradable, and environmentally friendly than traditional

synthetic dyes, which may include dangerous compounds that endanger ecosystems and human health (Taherirad *et al.*, 2024).

The negative impacts of synthetic dyes, such as water contamination from dye effluents containing heavy metals and other harmful compounds, have been extensively studied (Al-Tohamy *et al.*, 2022). On the contrary, natural dyes come from renewable resources, which is in line with sustainable practices (Jameel *et al.*, 2023). It is important to provide a safer alternative solution to synthetic dyed toys in order to protect children (Sepahi, Barani and Khazae, 2025). Use of natural dyestuff from bark of *Ficus benghalensis*. L (Indian banyan tree) provides a rich colour pigment which is non-toxic, skin-safe, non-carcinogenic, biodegradable and sustainable. In the tropics, *F. benghalensis* is grown primarily (Murugesu, Selamat and Perumal, 2021). In terms of distribution, *F. benghalensis* is the world's largest tree, with some native trees covering over an acre of land (Abdul Ahad *et al.*, 2021). Aqueous extraction was traditionally used to extract dyes from plants (Sivakumar, Vijaeswarri and Anna, 2011). The study proceeded with aqueous extraction of dye from *F. benghalensis*

The consumers are now highly aware of the hygienic life style and there is a necessity and expectation for a wide range of textile products finished with antimicrobial properties. The natural dyes are loaded with an abundant amount of phytochemicals, which provide characteristic functional finishing to the textiles where the trend of the textile industry shows a gradual change from fashion to functional apparel and healthy lifestyles (Kamboj, Jose and Singh, 2022).

3. Materials and Methods

3.1 Selection of Materials

The 100% baby soft 2 ply merino wool yarn was selected and purchased from Vardhman Textile Limited, Ludhiana for the current study. Bark of *F. Benghalensis* was collected from Ayurvedic store at Coimbatore. The natural mordants such as tamarind seed coat and cow dung were collected from the local market.

3.2 Herbal Dye Extraction Method

The bark of *F. Benghalensis* was collected and shadow dried for 3- 4 weeks until moisture of the wood is completely dried. Then grind the fragments into fine powder. The extraction of dye was done with different concentration by keeping MLR ratio, time and temperature constant and optimizing with quantity of dye powder. By optimizing with different concentration of dye, 20gm of powder in 50 ml of water gave rich colour.

3.3 Preparation of Mordant

1. The tamarind seeds were dry roasted for about 20 min and let it cool for some time. The seed coats were separated from seed using hand. Then the separated seed coats are ground into fine powder and stored in air tight container for further use.
2. The collected raw cow dung was shade dried for 1 weeks. The dried cow dung was crushed into powder and stored.

Dyeing of yarn

Dyeing was done with 10 gms of yarn. By optimizing with different concentration of dye, 20gm of powder in 50 ml of water gave rich colour. The same concentration was continued for the whole dyeing process.

Table:1-Dyeing of Yarn

Dyeing of Yarn	Pre Mordanting	Simultaneous Mordant	Post Mordant
Procedure	Pre mordanting method was followed for undyed yarn. The selected bio mordants Tamarindus indica (tamarind seed coat), bovine feece (cow dung) powder are used for mordanting the yarn before dyeing. The mordant wool yarn is washed, shadow dried. Now in 50 ml of dye stock solution is used for dyed for pretreated yarn for 60 mins at 90°C.	For simultaneous mordanting the raw yarn, mordant and the stock solutions are added simultaneous at a time and dyed. This is used for both the mordant individual. The stock solution and mordants are mixed well and boiled for 60 mins at 90°C with the wool yarn.	First the yarn is dyed with stock solution and then treated with bio mordants resulting in different colors.
Mordant concentration	25%	25%	25%
M; L ratio	1:20	1:20	1:20
Temperature	60°C	60°C	60°C
Time	35 Mins	35 Mins	35 Mins
Yarn	10 g of yarn	10 g of yarn	10 g of yarn
Mordant concentration	25%	25%	25%
M; L ratio	1:20	1:20	1:20

3.4 Assessment of Antimicrobial Testing

Qualitative Determination of The Antibacterial Activity of Treated Fabrics Agar Diffusion Method was carried out with the specimen of the test material was placed in intimate contact with Bacteriostatic agar, which has been previously inoculated (Mat culture) with inoculation of test organisms. After incubation, a clear are of interrupted growth underneath and along the side of the test material indicates antimicrobial activity of the treated cotton fabric.

- Culture Med-Bacteriostatic agar medium was used as a growth medium for the evaluation of microorganisms.
- Test Specimen-The dyed yarn, alcoholic extract of dye power, aqueous extract of dye stuff samples was cut into circular discs of 2cm diameter.
- Procedure-Sterile AATCC bacteriostatic agar was dispensed in sterile petri dishes 24 hours broth cultures of test organisms (Escherichia coli and Bacillus) were used as inoculums. Using sterile cotton swab the test organisms were coated over the surface of the agar plate. The test specimen was gently pressed in the center of the mat culture. The plates were incubated at 37*c for 18-24 hours.

3.5 Evaluation of Color Fastness

Dyed fabrics were then undergone different fastness tests viz. light, washing and rubbing etc. to optimize the best shade and best method of dyeing.

A. Color Fastness to Washing

Wash fastness of all dyed sample was measured by the ISO 105-C03 testing method. Dyed sample were taken, and converted into fabric by crocheting and was put to the bath containing 3gpl of soap, 2gpl of sodium carbonate and 1:3 MIR ratio at 60°C for 30 minutes. Then the specimen was washed with hot water and cold water.

B. Color Fastness to Rubbing

Rubbing fastness was tested using a crock meter by both dry and wet methods. A 5 cm × 5 cm crocheted fabric was rubbed against the dyed sample with ten full turns at one turn per second. Color change and staining were assessed using a grey scale, and the mean values were recorded..

C. Color Fastness to Sun Light

Sunlight fastness was tested by exposing dyed wool fabric (35 cm × 12 cm) divided into nine equal parts. Each section was exposed to sunlight sequentially, starting with the first, while the rest remained covered. After seven days, the exposed sections were compared to the unexposed fabric using a grey scale rating, and mean values were recorded.

3.6 Phytochemical screening- UV- Vis Spectroscopy Analyses

Separate aqueous extraction of dye extracted were dissolved with tamarind and cow dung mordants. A scan from 200 - 800 nm was performed in order to generate the characteristic absorption spectra of the sample. The absorbency of the solution was determined by scanning them.

3.7 Chemical Characterization of the Selected Herbal Combination -Fourier Transform Infra-Red Spectroscopy (FTIR)

FTIR spectra of *F. benghalensis* bark powder, tamarind mordant powder and the dyed sample were analyzed for test. The main constituent present in the samples is analysed.

3.8 Development of Product - Crocheting a Hammock

- Make a slip knot and chain 6. Slip stitch into the first chain to form a loop.
- Chain the length you want for one side of the hammock (18"). Then chain 6 more and slip stitch 6 chains back to form second loop.
- Row 1: chain 4, skip 2 stitches and double crochet in the third.(Repeat with C2, skip 2, Dc).
- Row 2: chain 4, double crochet into each chain-2loop. (Repeat with C2, Dc in the next loop).
- Turn, slip stitch center. Chain 6 for the third loop, slip stitch into the loop. Tie off and sew ends.
- Hence the toys are made with this procedure.

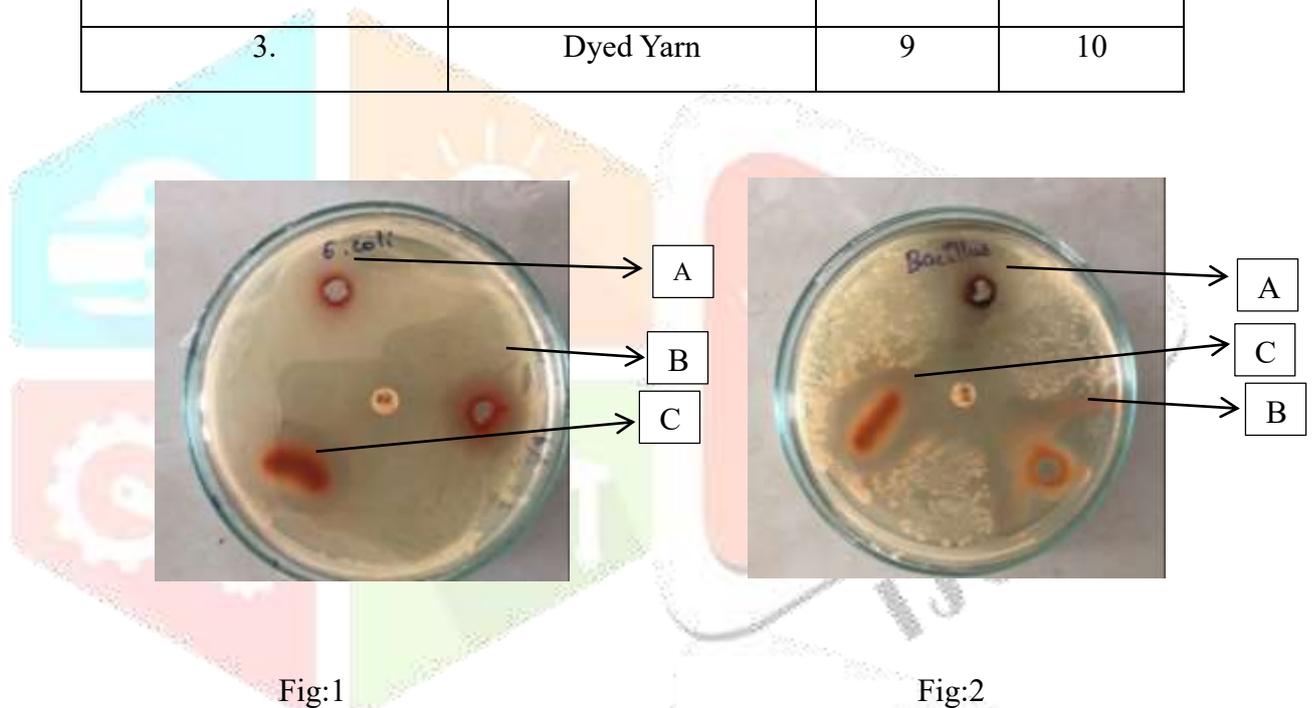
4 Results and Discussion

4.1 Qualitative Analysis of Antibacterial Activity of Dyed Yarn

The antibacterial activity of dyed yarn with their zone of inhibition was observed, calculated using formula 1 and tabulated (Table:2). It was clearly seen that the fabric treated with *Ficus benghalensis* showed superior antibacterial activity. It was also observed that the fabric treated with Aqueous extract showed no zone of inhibition.

Table:2 -antibacterial activity

S.No	Fabric Samples	Zone of Inhibition (mm)	
		E.coli	Bacillus
1.	Aqueous extract	0	0
2.	Alcoholic extract	10	13
3.	Dyed Yarn	9	10



(A, B, C represents A- Aqueous extraction, B- Alcoholic extract, C- Dyed yarn.)

Fig:1,2-inhibition of antibacterial activity

4.2 Phytochemical screening – UV -Vis spectroscopy analysis

Separate aqueous extractions of extracted dye were dissolved with tamarind and cowdung mordants. The solutions were scanned for absorbency analysis. The result shows that absorbency of tamarind seed coat is high than cowdung.

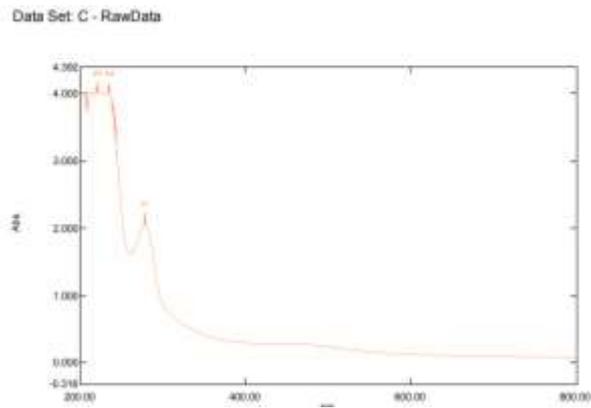


Fig:3

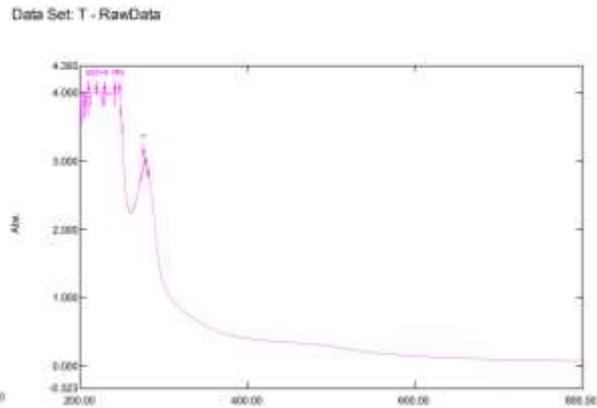


Fig:4

The given Figure (3) and (4) represents the absorbency wave length.

4.3 FT-IR spectroscopy analysis

FTIR spectra of Ficus benghalensis bark, tamarind mordant and the dyed sample was analysed for test. The main constituent present in the dyed sample was d_polyacrylamide_2.

1. SAMPLE ID: DYE YARN

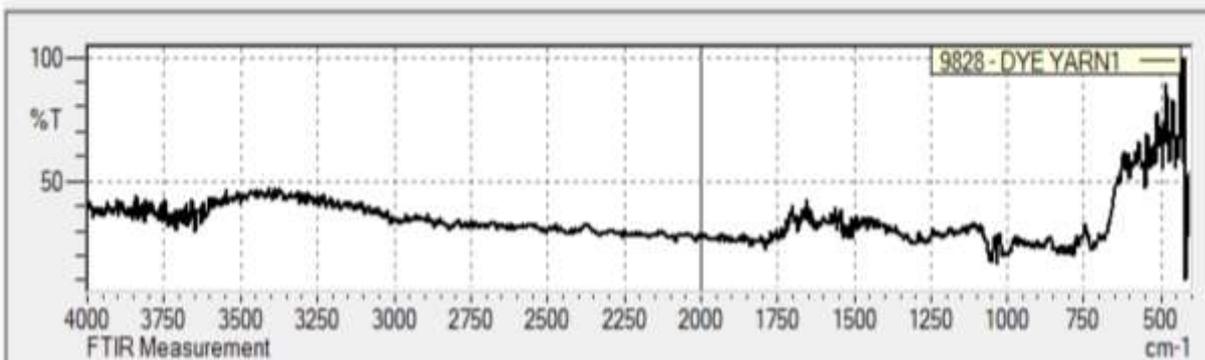


Fig:5-FT-IR spectrum peaks of dyed wool yarn

4.4 Colour fastness to Washing

- Washing of dyed yarn was moderate for first wash and good at second wash. The cow dung used as mordant didn't have good washability when compared to Tamarind seed coat

Table:3- colour fastness to washing

Sample	Mordant	Washing rate
Dyed Crocheted Sample	Tamarind Seed Coat	4
	Cow dung	3

4.5 Colour fastness to Rubbing

- The color fastness to rubbing by crock meter of dyed yarn with tamarind seed coat shows excellent as the dye uptake than with cow dung mordanting. Improved absorbency has reduced the texture and the surface pilling. This may play important role in reduced rubbing stain and color change in dyed yarn.

Table:4- colour fastness to rubbing

Sample	Mordant	Rubbing rate
Dyed Crocheted Sample	Tamarind Seed Coat	4
	Cow dung	3

4.6 Colour fastness to Sunlight

- Fabric dyed has proven to have good color fastness results in sunlight. The cow dung mordant fabric shows poor rating as it permits fading of color obtained in the process of dyeing.

Table:5- colour fastness to sunlight

Sample	Mordant	Sunlight rate
Dyed Crocheted Sample	Tamarind Seed Coat	5
	Cow dung	3

4.7 Determination of Wool Yarn Strength and CSP by Lea Strength Tester

- From this experiment the Lea strength of undyed samples cv% is higher than cv% of dyed yarn.
- This is concluded that the strength of dyed yarn is lesser than undyed yarn.

Table:6- determination of wool yarn strength and csp by lea strength tester

Reading	Raw Material	Yarn length (yds)	Sample wt. (g)	Yarn strength(lbs)	Cv%
1.	Undyed yarn	120	15.60	98.99	
2.	Undyed yarn	120	13.68	95	4.16
3.	Dyed yarn	120	16.43	86	
4.	Dyed yarn	120	17.49	93	3.86

4.8 Development of Product



Fig:6,7,8,9- product development by crocheting

5. Conclusion

Natural dyes produce an extraordinary diversity of colours that complement each other and are eco-friendly in nature. Phytochemical shows biological significance by playing an essential role in to defend themselves against various pathogenic microbes by showing the antimicrobial activity. Comparatively in the above study, testing was made on natural dyeing of *F.benghalensis* has obtained best hues and good result found in biological, phytochemical, physical and colour fastness test.

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