



Evaluation of Bactericidal Performances on Various Knitted Fabric Treated with the Natural Dye Extraction from Tagetes Erecta Leaves

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EVALUATION OF BACTERICIDAL PERFORMANCE ON VARIOUS KNITTED FABRIC TREATED WITH THE NATURAL DYE EXTRACTION FROM TAGETES ERECTA LEAVES

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Abstract- Preventing environmental pollution is the primary goal of obtaining natural dyes from available natural sources. The alkaline extraction process is used to extract dye from *Tagetes erecta* leaves. In 100% cotton and 60/40 CVC (60% cotton and 40% polyester) single jersey weft knitted fabrics, three different mordants (CuSO_4 , FeSO_4 , and $\text{K}_2\text{Cr}_2\text{O}_7$) are applied simultaneously. At 100°C as well as at room temperature, the dye fixing is done. Various shades of yellow, brown, and light green were produced when the dye was treated with a mordant. Comparing the dye fixed at 100°C to the dye fixed at room temperature, the dye at 100°C displayed dark colors and good fastness qualities. *Tagetes erecta* dye extract demonstrated significant antibacterial action against gram-positive bacteria (*S. aureus*), and FTIR was used to identify chemical components and functional groups.

Keywords: natural dye, antibacterial activity, knitted fabrics, *tagetes erecta*.

I. INTRODUCTION

Natural colors are frequently glossy, smooth, and calming to the eyes. A wide range of colors can be produced using natural dyestuffs. Many mordants are used to develop different colors. The artificial dyes don't create a wide range of colors, including unusual colors. Natural dyes are generally nonhazardous to human health, good for the skin, anti-allergenic, and safe for contact with skin (Saravanan P et al., 2013). Natural colors improve with age, but synthetic dyes deteriorate. The generalization that natural colors bleed but do not deteriorate with other textiles does not apply to turmeric. Since natural colors are frequently mothproof, they can alter synthetic dyestuffs in children's clothing. Natural dyes are utilized in textile dyeing, food coloring, beauty products, dye-sensitized solar cells, histology staining, and pH readings, among other things. (Paramasivam et al., 2022).

Since ancient times, *Tagetes erecta* flowers have been used traditionally. The leaves are applied to boils and used as an antiseptic including for piles,

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kidney problems, and muscular pain (Samanta & Konar, 2011). Fever and epileptic fits can be treated with the flower. According to Ayurveda, the juice of *Tagetes* flowers can be utilized to treat several ailments, including astringent, stomachic, carminative, and scabies, as well as liver problems and eye illnesses. They clean the blood, and flower juice is administered to treat bleeding piles. It is also used to treat colds, arthritis, and bronchitis. It was utilized by the Cherokee as a skin cleanser and to produce a yellow color (Shetty et al., 2015).

Flower juice is occasionally used as a blood purifier and piles treatment in numerous countries. In Brazil, *Tagetes erecta* flowers and leaves serve as a vermifuge. Flowers and leaf tinctures are used as diuretics and carminatives in Mexico. Marigold relieves stomach aches, joint pain, muscle spasms, anemia, irregular periods, and pain in the muscles and bones in Mexico and Brazil (Shetty et al., 2009). Internally, *Tagetes* was used to cure indigestion, cough, colic, and diarrhea. It is also used topically for ulcers, eczema, rheumatism, and painful eyes (Elumalai et al., 2012). When metallic salts are employed as a mordant mix with the fabric and dyes, metal complexes are formed. After mordanting, the metal salts adhere to the fibers and entice organic molecules there where they can bond with the fibers and get bonded to them. After that, it creates coordinating complexes to make a linkage between the molecules of dye and the fiber itself (Patil et al., 2016). A specific mordant that can react chemically with functional groups found in natural dyes and held together by coordinated or covalent interactions, hydrogen bonds, and other interactional forces combines with ferrous sulphate or other types of metallic mordants that are bonded to any fiber substances (Saravanan et al., 2013). In acid-base titrations, the methanolic extract of *Tagetes erecta* flower is employed as an acid-base indicator. Indicators for titration displayed discernible color changes at specific pH intervals (Geetha & Sumathy, 2013). The majority of indicators are organic dyes with synthetic origins. Today, acid-base titrations are chosen using synthetic indicators. The current study can be utilized to investigate the colorant behavior of *Tagetes erecta*



flowers and leaves, and additional testing is done on its potential usage as a natural dye (Elumalai et al., 2012).

II. MATERIALS AND METHODS

a) Materials

100% cotton and 60/40 CVC single jersey knitted fabric in the ready-to-dye stage (scoured &

bleached) was obtained from Masco Group (Gazipura 27, Tongi, Gazipur, Bangladesh). In Table 1, the fabric parameters are listed.

Table 1: Fabric Specifications

Fabric structure	Fabric Type	Count (Ne)	Grey WPI	Grey CPI	Finished WPI	Finished CPI	Weight GSM
Plain S/J	100% Cotton	30/s	31	50	34	53	145
Plain S/J	60/40 CVC	30/s	31	50	34	53	145

b) Gathering of Plant-Based Supplies

The *Tagetes erecta* plant was gathered from Uttarkhan, Dhaka, Bangladesh. The obtained flower samples were transferred to the lab after being firmly packaged in plastic bags. The petals of the flowers were divided and separated from one another. Then, to remove dirt and dust, the petals were briefly surface-cleaned under running water two to three times.

c) Chemicals

For the extraction of natural dye from *Tagetes erecta* leaves, all scientific-grade chemicals acquired from a local shop (Tongi, Dhaka, Bangladesh) were utilized.

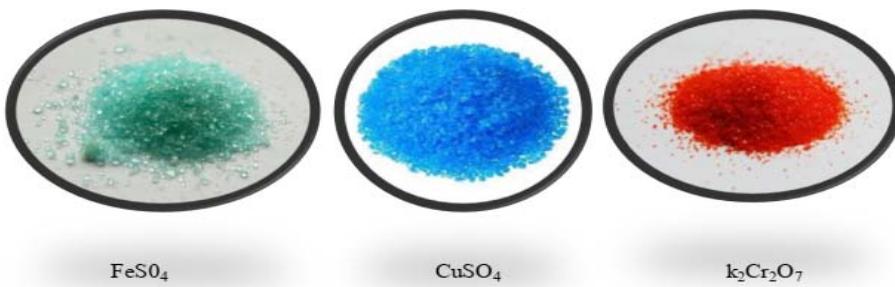


Figure 1: Different Mordants FeSO_4 , CuSO_4 , and $\text{K}_2\text{Cr}_2\text{O}_7$

d) Preparation of Dyeextraction

i. Alkaline Extraction

100 cc of distilled water dissolved 1gm of Sodium Hydroxide (NaOH). *T. erecta* petals weighing 10–20 gm were measured and stored in an alkaline solution. Finally, it was exposed to high heat for 30 minutes at 90°C. Whatman no. 1 filter paper was used to filter the dye. The acquired dye extract was kept in the refrigerator (Tripathi et al., 2015)

ii. Mordant Preparation

Separately, 1gm of copper sulphate, ferrous sulphate, and potassium dichromate was dissolved in 100 ml of distilled water.

iii. Fabric Preparation

Separately, 1gm of copper sulphate, ferrous sulphate, and potassium dichromate was dissolved in 100 ml of distilled water (Ahamed et al., 2017).

iv. The Dyeing Process using a Simultaneous Technique

With this technique, 100% cotton and 60/40 CVC fabrics were dyed using dye extract and several chemical mordants, which were then fixed at 100°C for 20 minutes. The ordinary dye table of the plant dyes was compared (Aglawe et al., 2019).

III. CHARACTERISATION

a) Lightfastness

The fabric was left out in the sun for 24 hours. Colorfastness (IS-2454-85) was determined by comparing the color change of the subjected part to the color change of the original material that had not been exposed (Aglawe et al., 2019).

a) *Washing Fastness (IS-687-79)*

The colored samples were sandwiched between two white, uncolored samples. These three separate parts were stitched together at the edges. The sandwiched fabric was placed in a vessel with the

preheated soap solution (Tide at 55°C in the ratio of 1:50, i.e., 0.5g/25 ml water) and left for 45 minutes. The cloth was then taken out and washed in cold water (Nasrullah et al., 2012).



Figure 2: a. *Tagetes erecta* plant; b. Grinding; and c. Liquid Dye Extraction

b) *Evaluation of Antibacterial Assay*

The inhibition zone was determined using the Kirby-Bauer disc diffusion test and the antimicrobial efficacy of the experimental samples against the *Staphylococcus aureus* bacterium. On tryptone soya agar media, fresh subcultures of the bacterial strain (*S. aureus*) were created. Nine milliliters of tryptone soya broth were inoculated with one loopful of a freshly cultivated colony. From a newly cultured plate, one loopful of a colony was taken and used to inoculate 9 ml of tryptone soya broth. After that, the mixture was overnight kept at 37°C in an incubator to get the desired turbidity of 0.5 Mc Farland Standard (1.5×10^8 CFU/ml). The bacterial culture was sequentially diluted in normal saline to a bacterial cell concentration of 1.5×10^5 CFU/ml. After evaluating the samples, the zone of inhibition (ZOI) was identified (Sun, 2016). Pelletizing

knitted cloth into a 13 mm diameter disc on an agar plate produced the sample for the experiment. Samples were then incubated for 24 hours at 37°C. After incubation, the plates were examined to check for the zone of inhibition encircling the treated sample (Gokarneshan, N & Velumani, 2018).

c) *Evaluation of Bonding Behavior by FTIR*

The materials were analyzed using Fourier transform infrared spectroscopy (FTIR) (IR Prestige 21, Shimadzu, Japan). According to the infrared absorption with a resolution of 4 cm^{-1} and a frequency range of $600\text{--}4000 \text{ cm}^{-1}$, spectrum data from the automated spectros copyprogram was used to pinpoint the precise chemical groups that predominated in the sample (Badr et al., 2016).

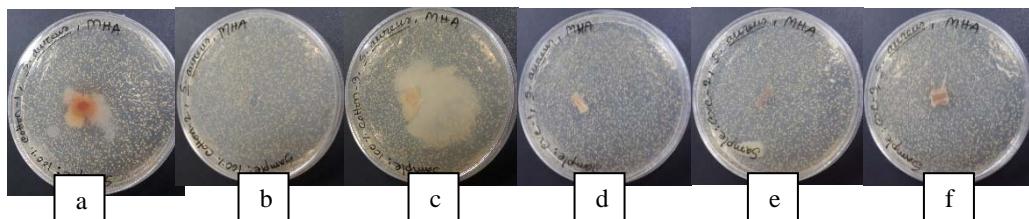


Figure 3: Inhibitory Zone Formation Surrounding Developing Samples (a. 100% cotton with FeSO₄; b. 100% cotton with CuSO₄; c. 100% Cotton with K₂Cr₂O₇; d. 60/40 CVC with FeSO₄; e. 60/40 CVC with CuSO₄; f. 60/40 CVC with K₂Cr₂O₇)

d) *Measurement of Color Strength*

K/S values were used to determine the color strength of the dyed 100% Cotton and 60/40 CVC fabrics. The dyed materials' light reflectances were measured with a Text flash spectrophotometer (Data Color Corp.). The Kubelka-Munk equation was used to calculate the K/S values.

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

Where R is the decimal fraction of the colored fabrics' maximum light reflectance (λ_{max}). The absorption

coefficient is K, while the scattering coefficient is S (Habibzadeh et al., 2010).

IV. RESULTS & DISCUSSION

a) *Evaluation of Light Fastness Properties*

Excellent to moderate light fastness at 100°C fixed on 100% cotton and 60/40 CVC fabrics. The alkaline dye-extract of *T. erecta* with the mordant CuSO₄, FeSO₄, and K₂Cr₂O₇ showed excellent to moderate light fastness at 100°C fixed 100% cotton and 60/40 CVC (Table 2). Likewise, the test specimen was dyed using



marigold leaf extract and mordanted with iron and copper sulphate resulting in good light fastness. The resistance to dye attack is an inherent property of the

dye chromophore, however, the auxochrome can also significantly affect the fastness.

Table 2: Light Fastness Properties (IS-2454-85) of Samples Dyed with Leaves Extract from *T. Erecta*

Dye Extracts	Mordants	100% Cotton	60/40 CVC
Tagetes erecta dye extract at 100°C	Ferrous sulphate	Excellent	Good
	Copper sulphate	Excellent	Moderate
	Potassium dichromate	Excellent	Moderate

b) Evaluation Of Wash Fastness Properties

At 100°C fixed 100% cotton and 60/40 CVC materials, the washing fastness of *T. erecta* dye extract ranged from mild to good. At 100°C, 100% cotton and 60/40 CVC fabrics showed good washing fastness with mordant $FeSO_4$ (Table 3). Likewise, the exceptional washing fastness of Cordia Sebestena flower extract dye can be successfully utilized for dyeing silk to achieve a wide range of soft and light colors by

combining mordants. Using varied temperatures (50°C, 60°C, and 70°C) and different washing fastness hours (6h, 7h, and 8h) of various chemical mordants, the color fastness characteristics of the colorant derived from the bark of acacia leucophloea on cotton have been examined. In the current study, various mordants were used for dyeing fabrics made of bleached cotton and CVC (Shinde et al., 2010).

Table 3: Wash Fastness Properties (IS-687-79) of Samples Dyed with Leaves Extract from *T. Erecta*

Dye Extracts	Mordants	100% Cotton	60/40 CVC
Tagetes erecta dye extract at 100°C	Ferrous sulphate	Good	Moderate
	Copper sulphate	Good	Mild
	Potassium dichromate	Moderate	Mild

c) Mordant Optimization using K/S Values and Color Hue Shifts

Various hues of color were obtained from post-mordanted cotton and CVC fabric with ferrous sulphate, copper sulphate, and potassium dichromate as shown in table-4. Different mordants alter the brightness index values, L^* values, and K/S values in addition to affecting color shades and K/S values significantly (Jeyakodi & Venkataraman, 2015). The effect of mordants on color values of cotton and CVC fabrics dyed with leaves of *Tagetes erecta* is shown in Figure 4. Table 5 displays

the values for L^* , a^* , b^* , and K/S. As can be observed, mordants with higher L^* values produce lighter hues, while those with lower L^* values provide deeper shades for the sample fabrics. Similarly, green and blue are represented by negative values for a^* and b^* , respectively. Among the chemical mordants used, the highest color value ($K/S = 65.203$) was obtained with ferrous sulphate, and the lowest color value ($K/S = 23.985$) with Potassium dichromate. 60/40 CVC fabric showed a higher color value than the 100% cotton fabric.

Table 4: Color Produced on Cotton and CVC Fabric by Different Mordants in Post-Mordanting (POM)

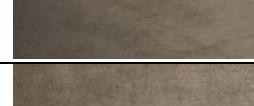
S. No.	Fabric type	Mordants	Color Obtained	
1	100% Cotton	Ferrous sulphate		
2	100% Cotton	Copper sulphate		
3	100% Cotton	Potassium dichromate		
4	60/40 CVC	Ferrous sulphate		
5	60/40 CVC	Copper sulphate		
6	60/40 CVC	Potassium dichromate		

Table 5: L*, a*, b*, and K/S Values for Cotton and CVC Fabric Colored with *Tagetes erecta* Leaves, in Addition to others Post-Mordants

S. No.	Fabric type	Mordants	L*	a*	b*	K/S value
1	100% Cotton	Ferrous sulphate	69.817	0.599	19.785	65.203
2	100% Cotton	Copper sulphate	73.247	1.974	27.355	35.837
3	100% Cotton	Potassium dichromate	77.154	1.602	15.379	23.985
4	60/40 CVC	Ferrous sulphate	65.020	0.297	12.510	62.529
5	60/40 CVC	Copper sulphate	74.857	1.865	13.257	39.789
6	60/40 CVC	Potassium dichromate	74.300	0.495	9.741	36.946

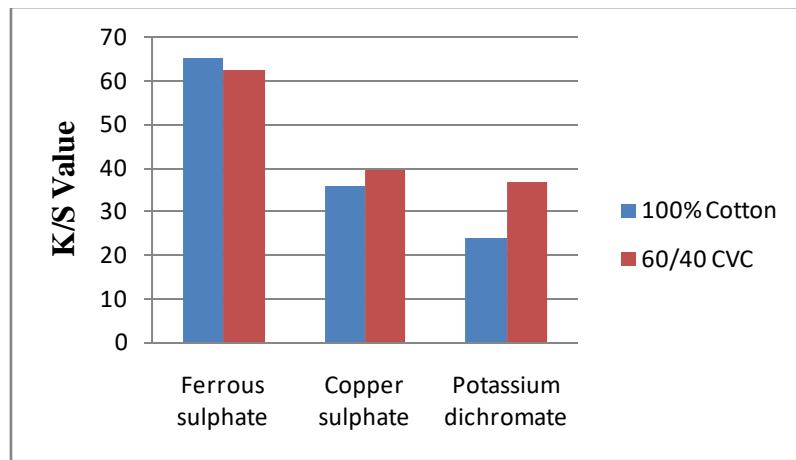


Figure 4: Post-Mordants' Impact on the Color Values of Dyed Cotton and CVC Fabrics

d) *Antibacterial Efficacy of the Alkaline Dye Extract from *Tagetes erecta* s*

The dye extract showed average antibacterial activity against *Staphylococcus aureus* bacteria. Among the six samples with three different mordants, 60/40 CVC samples dyed with *T. erecta* leaves extract along with copper sulphate as mordants showed more effectiveness against *S. aureus* bacteria where the zone

of inhibition was 6 ± 0.54 mm as shown in Table 6. In contrast, ferrous sulphate-containing samples showed less effectiveness against the bacteria. Moreover, 60/40 CVC samples showed higher results of antibacterial efficacy than 100% cotton samples because polyester fiber itself influences bacterial resistance due to its hydrophobic nature (Pekhtasheva et al., 2011).

Table 6: Antibacterial Efficacy of Alkaline Dye Extract from Leaves Of *T. Erecta*

Sample	Mordants	Bacterial cell concentration (CFU/ml)	Sample weight (gm)	Disk size	Zone of inhibition (ZOI)
100% Cotton	Ferrous sulphate	1.5×10^5	5	7 mm x 7 mm	3 ± 1.7 mm
100% Cotton	Copper sulphate	1.5×10^5	5	7 mm x 7 mm	4 ± 1.9 mm
100% Cotton	Potassium dichromate	1.5×10^5	5	7 mm x 7 mm	4 ± 1.4 mm
60/40 CVC	Ferrous sulphate	1.5×10^5	5	7 mm x 7 mm	3 ± 0.86 mm
60/40 CVC	Copper sulphate	1.5×10^5	5	7 mm x 7 mm	6 ± 0.54 mm
60/40 CVC	Potassium dichromate	1.5×10^5	5	7 mm x 7 mm	4 ± 1.7 mm

e) *FTIR Spectra Investigation of the Dye Extracted from *T. Erecta* s*

By using FTIR spectroscopy, developed samples of both 100% cotton and 60/40 CVC were examined to verify the requisite functional groups and internal bondings. Figure 5 depicts cotton fiber's FTIR spectrum, where typical bands of cellulose, lignin, and hemicellulose may be seen whereas in 60/40 cotton-

polyester (figure 6) fabric sample, the FTIR spectra emerge the strong peaks like cotton and weak peaks like polyester due to the proportion of fiber composition (Lam et al., 2012). The *T. erecta* dye extract showed more absorption bands at 3286.7, 2929.87, 1955.82, 1718.58, 1365.6, and 721.38 that were assigned to the alcohol as a functional group, including O-H stretching, C-H stretching, N=C=S stretching, N-H bending, and

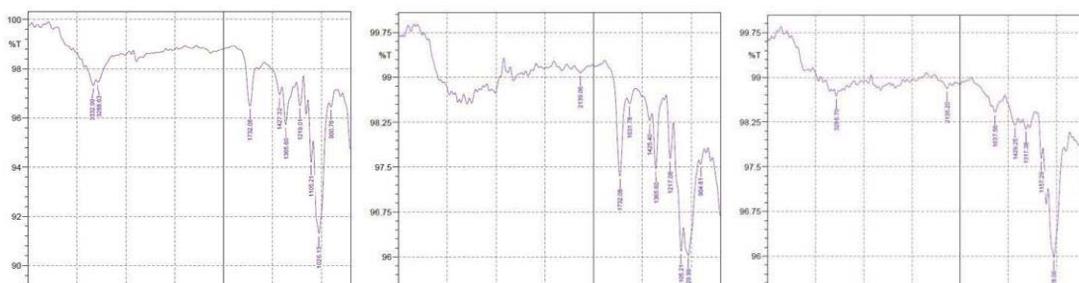


Figure 5: FTIR Band Spectra of 100% Cotton with Mordant a. FeSO_4 ; b. CuSO_4 ; c. $\text{K}_2\text{Cr}_2\text{O}_7$

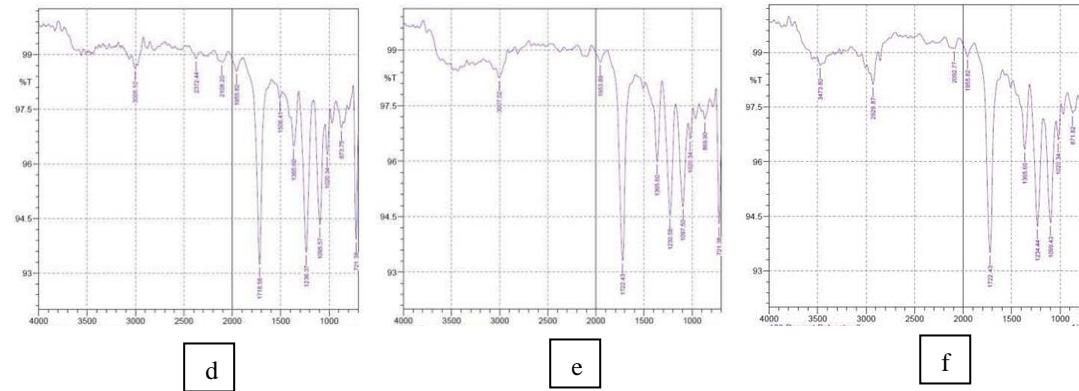


Figure 6: FTIR Band Spectra of 60/40 CVC with Mordant a. FeSO_4 ; b. CuSO_4 ; c. $\text{K}_2\text{Cr}_2\text{O}_7$

V. CONCLUSION

Natural dye has a great opportunity in the usage of textile coloring due to its nonhazardous characteristics to the environment. The study found that the alkaline dye extract of *T. erecta* may be successfully used for dyeing cotton and CVC fabric when combined with various mordants. Dyeing with mordants had good washing and lightfastness, and the dye extract showed antibacterial efficacy. Moreover, the alkaline solution of leaf extracts of *T. erecta* showed satisfactory color strength and light reflectance. The dye has a wide range of scope in commercial cotton dyeing.

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