INVESTIGATION OF THE COLORFASTNESS PROPERTIES OF NATURAL DYES ON COTTON FABRICS

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Abstract: *The aim of this research was to identify the color fastness properties of the natural dyes on cotton fabrics using different types of dyes like mehedy/henna, turmeric, tea leaf and pomegranate, which were cheap, easily obtainable and ecofriendly. The findings established that, mehedy/henna dye reacted with cellulose of cotton in alkaline condition to form a permanent covalent bond between the dye and the cellulose, which would not be removed by frequent washing treatment with steaming water in neutral conditions and exposed excellent color fastness properties. Mehedy dye had a reactive group that acted as an integral part of fiber and this covalent bond was formed between the dye molecules and the terminal reactive group. With necessary treatments these dyes were collected from nature in powder form and liquefied them for dyeing on 100% cotton mercerized fabrics with necessary chemicals and auxiliaries as natural dyes had affinity towards cellulosic fibers. Continuous dyeing process was carried out with the facilities of "Pad Dye Pad Steam" machine in open width form and then steamed wash to fix the colors with natural dyestuffs. Dyeing process and color fastness tests were carried out in accordance with the test method provided by AATCC and ISO standards. Dye absorption and color strength tests were conducted with the facilities of lab spectrophotometer "Data Color Spectra Flash SF600" in agreement with Kubelka Monk equation through the spectral reflectance, absorption and scattering characteristics of the samples. "Nicolet IS 50 FTIR" instrument was applied to attain the color intensity properties through the passage of Infrared Radiation (IR) within the spectrum. This research was practice based and the findings were advantageous to the personnel involved in textile industries who were responsible for dyeing the fabrics with natural dyes and to controlling of their color fastness properties.*

Keywords: *Natural dyes; color fastness; FTIR; spectrophotometer; dye absorption; color strength; color intensity; infrared radiation.*

1 INTRODUCTION

The research under discussion was undertaken in the field of cotton fabric dyeing with natural dyes which were economical, simply accessible in nature and sustainable. There is a great importance of this research in textile and clothing engineering since the task of dyeing the cotton fabrics with natural dyes were always challenging due to the poor colorfastness properties. Dyeing processes were conducted in textile mills and they involved the application of natural dyestuffs along with necessary chemicals and auxiliaries. The research may be considered important in textile wet processing zone since the dyeing of fabric with natural dyes can reduce the impact on the environment resulting from the disposal of toxic chemicals due to the application of ecofriendly substances. Different researcher worked related to this subjected matter at different times, where literature review exposed different results. For an example, due to the variety of variable involved, if one constraint was changed during experimentation, then there was also a change in the other property of fabrics, and this investigation was carried out with some substances obtained from nature. While experimenting with the cotton fabrics, it was observed that if one condition or amount of chemical or auxiliaries was changed, then there was an unexpected change occurred in the fabric's color fastness properties or the fabric's color staining properties [1]. Ford et al [2] reported that some dyestuff like indigo or lichen showed good color fastness property during dyeing. These dyes were known as direct dyes or substantive dyes since the majority of natural dyes necessitate the application of a mordant, which was applied to "fix" the color in the textile fibers. These dyes were also called sustainable dyes. These dyes were ecofriendly and did not do any harm to the environment. Kabir et al [3] reported that by applying various mordants with dyes, dyers can obtain outstanding colors and shades. Fibers or fabrics were treated with mordants and these mordants were integrated in the same dye bath [4]. In the customary dyeing process, the conjoint mordants included substances such as vinegar, oak galls, ammonia and potassium made with wood ashes were dissolved in the dye bath [5]. Shabbir et al [6] reported that natural dyes were prepared from fruits, leaves, flowers, nuts and berries. These colors were extracted easily and were dyed on fabric quickly. Adeel et al [7] also reported that natural dyes were less bright than synthetic dyes but these natural color components were sustainable and biodegradable. Dyeing of fabric with natural dyes was cost effective. Rather et al [8] reported that most of the synthetic dyes were prepared from chemical compounds those were not always welcoming for the human. On the other hand all the natural dyes were suitable for human and these dyes did not do any harm to the skin [9]. Mir et al [10] reported that textile fibers were dyed before spinning if "heather effect" was wanted on fabrics. "Heather" is the process of dyeing the fibers before producing yarn. Yarns could be dyed before producing fabrics which was called yarn dyed fabrics. In fabric dyeing process, fabric is dyed at wet processing zone that is the most common process of dyeing [11]. Shahid et al [12] also reported that garment dyeing was costly and there remained more chances to damage the cloths. Dyeing at fabric stage can give good effect compared to garment dyeing stage. Baig et al [13] experimented that mordants were necessarily required to fix the colors on fabric and also to bind the color compounds to the textiles fibers or fabrics. Shahidul Islam et al [14] reported that synthetic dyes were prepared for commercial use and thoughts for profit. But natural dyes were not prepared for commercial use and these dyes were prepared for human welfares [15]. If these natural dyes compounds were be produced in large volume then ecological impact could be enhanced [16]. Patel et al [17] reported that synthetic dyes were produced for economical reason in huge extent. On the other hand natural dyes were prepared for dyeing cellulosic fibers without any ecological hazard. Fan et al [18] experimented that natural dyes were produced for obtaining light shades with true colors but synthetic dyes were produced for obtaining bright colors with deep shades, which were suitable for textile dyeing and printing. Tiwari et al [19] reported that the awareness should be increased to use the natural dyes in great extent. Consumers from the western countries were more conscious about the health issues. The environmental influence of synthetic dyes for engineering and manufacturing showed great demand for the products and quality requirements [20]. Western union inspired their nations to use ecological substances for dyeing with locally available natural dyes [21]. Wang et al [22] also reported that cellulose fibers need direct or substantive dyes which were generally known as vat dyes those were colorless and could be fixed suitably in the presence of light or oxygen. Protein fibers needed mordants to create bonding with the medium and the substance. Each synthetic fiber needed individual dyeing technique [23]. Likewise nylon needed acid dyes, rayon needed disperse dyes those were suitable for vat dyeing application [24]. Kumbhar et al [24] explained that the manmade chemical compounds used in textile fabrics showed hygiene problems. Natural dyes like indigo blue had a reactive group in its chemical structure [25]. During that time, it was impossible to define the functional group for indigo dyes. People used them in great extent, produced them in great extent and exported them in great extent with lower expenses [26]. The majority of the natural dyes are obtained from floras, flowers, leaves or vegetables from plant sources like roots, berries, barks, wood and other organic sources like mildews and lichens [27]. Blue, red, yellow, brown and violate dyes were obtained from natural vegetables or plant sources throughout the Indian subcontinent [28]. Su et al [29] also explained that the important procedure of dyeing needed to saturate the materials comprising with the dye particles in water, adding the substances to dye in the solution or dye bath. It should be continued with solution up to a required period till the color started to transfer from aqueous medium to the textile substances [30]. Velmurugan et al [31] also reported that reactive dyes have a chromophore group that is responsible for reacting with the substrate. These dyes have good color fastness properties due to the covalent bond that is established while dyeing. Patil et al [32] reported that salt was used while dyeing to increase the color fastness properties of the textile materials. Vinegar was beneficial to improve the shade of red and purple color. Ammonia-stale urine was useful in the fermentation of natural indigo dyes [33]. Natural alum or known as Aluminum Sulfate was the utmost popular metallic salt mordant [34]. The iron mordants aided fabric deterioration which was known as "dye rot" [35]. Benli et al [36] reported that additional compounds were used while dyeing to improve the color shades. Rehman et al [37] also reported that different natural plants like lichens, henna, alkanet and avocado pits produced red dyes. Kilinc et al [38] reported that madder was a dye that was produced commercially in the Western Union and in the Eastern Europe to dye the red coats of military person in 1869. Jafari et al [39] also informed that the madder was applied for dyeing the "hunting pinks" in Great Britain. Rehman et al [40] also reported that in the Western Europe and in the Eastern Europe the colors like purple and violet were similar colors and they were manufactured by dyeing wool with indigo. Mongkholrattanasit et al [41] experimented that madder might produce purple shade during dyeing with potash alum. Brazil wood could produce purple colors while dyeing with blue vitriol.

2 EXPERIMENTAL PART

2.1 Materials used

100% cotton plain woven fabric was used in this research. The construction of the fabric was 20×16/130×70 meant that the count of the warp yarn was 20 Ne and the count of the weft yarn was 16 Ne. Warp ends per inch (EPI) in warp way was 130 and weft picks per inch (PPI) in weft way was 70. The weight of the fabric was 280 g/m^2. The width of the fabric was 56″.

Mehedy/Henna leaf dye

Henna is known as mehedy, which is a natural dye particle, prepared from the plant leaves. Henna is most commonly used from ancient times to dye skin, hair and fingernails and also fabrics made up of cotton, silk, wool, etc.

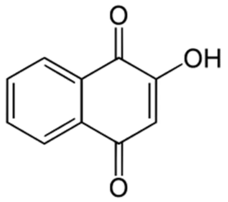


Figure 1 Molecular structure of henna leaf

Turmeric powder dye

Turmeric is a bright yellow colored natural compound that is extracted from the roots of several species of the ginger family. Turmeric powder is also used to dye the fabric and the yarns.

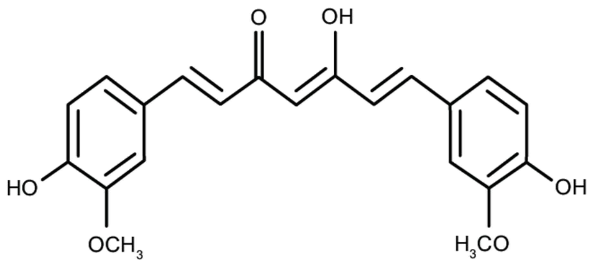


Figure 2 Molecular structure of turmeric powder

Pomegranate dye

Pomegranate is a fruit bearing shrub that is very deciduous and now it is being used to dye fabric. This is pinkish color and gives a mild light shade to the fabric and to the yarn.

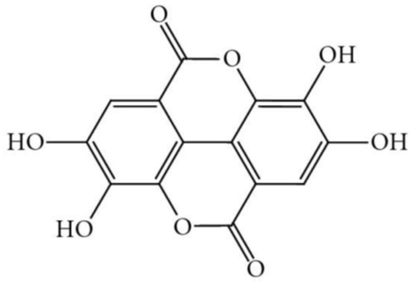


Figure 3 Molecular structure of pomegranate

Tea leaf dye

Tea is a sweet smelling liquid product that is produced by pouring boiling water in a cup. This natural color bearing compound is now used to dye fabrics, fibers and yarns.

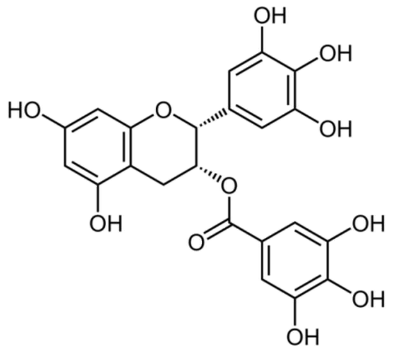


Figure 4 Molecular structure of tea leaf

Chemical and auxiliaries used

Various chemical compounds showed in Table 1 were used in this research during dyeing the specimens.

Table 1 Chemicals and auxiliaries used in this research

S.N	Trade/chemical name	Chemical formula	Medium	Function
1	Hydrogen peroxide	H_2O_2	acidic	an oxidizing agent used to produce oxygen and sodium carbonate
2	Wetting agent	$C_{20}H_{37}NaO_7S$	alkaline	reducing surface tension of water
3	Leveling agent	$C_{17}H_{25}OSO_3Na$	alkaline	to enhance the migration and leveling of dyes
4	Salt	NaCl	alkaline	to enhance dye exhaustion
5	Acetic acid	CH_3COOH	acidic	to eliminate extra dyes from fabric surface
6	Soap	$C_{18}H_{35}NaO_2$	alkaline	to wash up the fabric
7	Fixing agent	$(NH_4)_2S_2O_3$	alkaline	to fix the dye
8	Soda ash	Na_2CO_3	alkaline	to maintain the pH
9	Sequestering agent	$C_{15}H_{10}Cl_2O_3$	alkaline	to remove water hardness

2.2 Method used

Kubelka monk defines an equation (K/S) with the spectral reflectance, absorption and scattering characteristics of the sample. CIE states an equation for the total color difference ∆E* that was measured with the term ∆L*, ∆a*, ∆b*, ∆c* and ∆h* with the equations (1) and (2).

$$\Delta E*ab = [(\Delta L*)2 + (\Delta a*)2 + (\Delta b*)2\ ]½ \quad (1)$$

$$\Delta H*ab = [(\Delta E*ab)2 - (\Delta L*)2 - (\Delta C*ab)2]½ \quad (2)$$

Light Fastness Tester TF421 was used to test the color fastness to light of the specimen. The purpose of light fastness testing was to subject the tested samples to artificial light to evaluate the influence on the material against day light while using by the end user.

Launder meter TF418 was used to test the color fastness to wash of the specimen. The property of a dyed sample, which hold its color when the dyed material were subjected to laundering or washing from being washed away was known as wash fastness.

Perspirometer TF416A of Testex was used in this research to test the color fastness to perspiration of the specimen. This instrument was used to determine the perspiration fastness of fabrics, which contains 1 stainless steel frame with 21 acrylic separator plates to hold the samples.

Color fastness to crocking was tested by crock meter TF410 to dry and wet condition of fabrics. The crock meter was modeled with an electronic counter that had a handle in its top to function smoothly. Sandpaper was set under the tested sample for the purpose of crocking the specimen.

FTIR instrument Nicolet IS 50 FTIR was used in this research to get the colorfastness properties and the color intensity properties of the natural dyed cotton fabrics through the refrection of Infrared Radiation (IR) within the sprectrum.

Data color spectra flash SF600 lab spectrophotometer was used in this research for getting the color strength and color measurement values. It had duel beam transmission system with xenon rays illumination. It can work in the spectral analyzer of dual 256 diode array with high resolution holographic grating system. It can work in the wavelength range from 360 nm to 900 nm.

Pad dye pad steam is a dyeing machine of continuous fabric dyeing, where the fabric is dyed in open width with dyestuff and is then steamed. Steaming is the process of fixing the colors with natural dyestuffs. Light, medium and heavy shades can be achieved with this dyeing machine. Steamer was used for diffusion of reactive, vat, sulphur, direct and natural dyes into cellulosic fibers in a thermosphere condition created by inundated steam vaccinated into the steamer.

Figure 5 shows the sample dyeing process with pad dye pad steam machine [42].

Figure 5 Sample dyeing process in pad dye pad steam machine

2.3 Dye extraction process

Henna dye extraction process

Henna leaves were collected from the plant. The leaves were washed away to remove dust and adhering material. The leaves were then dried in heavy sunlight. The dried leaves were then crushed into powder for dye extraction with a grinding machine. 500 gram henna powder was taken in Na_2CO_3 solution for 24 hours in room temperature with the pH level of 8-9. The henna solution was reddish orange color. The solution was saturated with Na_2CO_3 solutions till the color was detached from powder to the aqueous medium. Reddish orange color of henna was developed at the presence of alkaline solution.

Acetic acid was mixed at the alkaline reddish orange color solution of henna to make the pH neutral. As it was natural dyes compound, 5 ml of chloroform was mixed at the solution to protect it into a funnel. The solution was dried with anhydrous sodium sulfate. The solution produced orange yellow color. The solution was kept away from light till chloroform was evaporated. Then the solution was kept separately for storage.

Turmeric dye extraction process

Raw turmeric was collected from garden. Fresh turmeric were cleaned, washed off in clean water, sliced and dried in the sunlight for a week. The cleaned turmeric was dried at 40°C for 6 hours at oven. The dried turmeric was cut into small pieces and then powdered in a grinder. The powder was air dried in sunlight for 12 hours to remove moisture. 500 gram powder of turmeric was taken into a funnel and placed in a sox let apparatus. 500 ml water was added and extracted for six hours at boiling temperature. The solution was passed through a colander of 30 mesh size to get uniform liquor so that uniform dyeing was possible. As this was natural dyestuff, chloroform was sued in this solution for perseverance.

Pomegranate dye extraction process

The pomegranate fruits were collected from garden and then they were piled off from their skin. Pomegranate pills were taken out to extract the dyes. Pomegranate pills were crushed with a juicer or grinder and taken their juice was taken out of it. 500 ml juice was taken into a funnel and boiled at 100°C. The solution was passed through a colander of 30 mesh size to get uniform liquor so that uniform dyeing was possible. As that was natural organic dyestuff, some natural destructive conditions like weather, oxygen, light and all other environmental gases can fade and destroy certain colors. Therefore, natural dyestuffs should be preserved after finishing in boiling temperature. Chloroform was used in this solution for perseverance.

Tea leaf extraction process

Green tea leaf was collected from the plant. The leaves were washed away to remove dust and adhering material. The leaves were then dried in sunlight. The dried leaves were then crushed into powder for dye extraction with a grinding machine. 500 gram tea powder was taken in CH_3COOH solution for 12 hour in room temperature with the pH level of 3 to 4. The color of tea leaf was extracted in aqueous medium. Tea leaf was acidified with the pH range of 3.0 to 4.0 at aqueous solvent with boiling temperature for 7 to 8 minutes at the air pressure of 90 to 100 PSIG to provide a high temperature acid extract. The color bearing acid extract was used to dye the textile materials with necessary auxiliaries and substrate.

2.4 Dyeing process

Dyeing of cotton fabric with henna dye

Cotton fabric was cationized prior to dyeing with henna dye. 70 grams of (3-chloro-2-hydroxypropyl) trimethylammonium chloride was liquefied in 300 ml deionized water. 30 grams of sodium hydroxide was then mixed to form (2, 3-epoxypropyl) trimethylammonium chloride (EP3MAC) solution. After that the fabric was saturated with EP3MAC solution at 60°C for 18 min and then it was padded at 21 meter per minute speed with the pressure of 1 kg/cm^2. The fabric was then covered in an elastic film by 24 hours at 30°C for averting the passage of chemicals on the fabric and desertion of water. Afterward, the fabric was simply washed twice with clean water and neutralized with acetic acid solution by 5 g/l ratio. Lastly, the fabric was again washed to get a neutral pH of 6 to 7 and then it was dried and collected in a batcher. Henna dye solution was used to dye the cationized cotton fabrics without addition of salt. Cotton fabrics were submerged in a dye bath composed of henna dye solution and sodium carbonate solution of 15 g/l, using dye liquor ratio of 1:20. The process of dyeing was conducted at the temperatures of 60°C for 30 min at the pH medium of 6 to 7. After dyeing the cotton fabric washing was done at first in clean water subsequently in detergent water of 2 g/l, Na_2CO_3 10 g/l, liquor ratio 1:25 at 90°C for 8 minutes. Finally, the dyed fabrics were dried and collected safely.

Dyeing of cotton fabric with turmeric dye

At first the cotton fabric was submerged in mild detergent solution (about 15%) and kept it for 12 hours. Then the fabric was washed off with clean water with acetic acid to make the pH 7 and then dried. It was better if the fabric can be dried with sunlight. Turmaric dye was prepared by extracting turmeric powder from de-ionised water at neutral pH. The applied temperature was 95°C for 1.5 hours. Turmeric dye extract had the color of yellow. The liquor ratio of the water and turmeric extract was 15 g/l using liquor ratio of 1:20 with the temperature of 60°C for 30 minutes at the pH medium of 6 to 7. After dyeing the fabric, the sample was washed in normal clean water with the presence of acetic acid to make the pH level neutral.

Dyeing of cotton fabric with pomegranate dye

Cotton fabric samples were treated with two mordants such as ferrous sulphate and copper sulphate for 1 hour at 75°C. The technique of pre-mordanting was applied with the liquor ratio of 1:20. The samples were washed after mordanting and dried at 30°C and then used for dyeing process. Cotton fabric was dyed with pomegranate peel extracted dye solution. The dyeing process was carried out at 90°C to get better results. The cotton sample fabric was dyed for 1 hour with the liquor ration of 1:20. After dyeing, the sample was washed off with clean water at 30°C. At last the sample was dried and kept in store for testing purpose.

Dyeing of cotton fabric with tea leaf dye

Mercerized cotton fabric was used for dyeing with natural tea leaves dyestuff. The fabric was treated with 5 g/l of acetic acid in aqueous medium at 30°C to make the pH neutral. The dyeing process was conducted with 90°C in continuous dyeing machine at the speed of 40 m/min to get better results with the liquor ration of 1:20. After that, the sample was washed with detergent at 30°C to clean the unfixed dyestuff. Again, the fabric was washed with 5 g/l of acetic acid in aqueous medium at 40°C to make the pH neutral. Finally, the sample was dried and kept in store for testing purpose.

2.5 Dye absorption and color measurement test

Dye absorption and color strength of the dyed cotton fabrics were measured with the facilities of the instrument of spectrophotometer SF-600. Sample fabrics were cut in the size of 3″×2″ to place it in the instrument. For getting the spectro-photometer reading, the jack of the instrument was opened and then the sample fabrics were placed inside it. Color strength values K/S, color shade L*, a*, b*, C* and h* values were taken as shown in Table 2. Spectrophotometer used tungsten halogen lamp as the most common light source, which was comprised of tungsten filament light with a wavelength number of 330 nm to 900 nm inside the visible region.

2.6 Color fastness test

Color fastness test of the cotton fabrics were carried out in accordance with the test method provided by ISO Standard. Color fastness to light was conducted in agreement with the test method provided by ISO 105-B02 Standard. Color fastness to rubbing was conducted in agreement with the test method provided by ISO 105-X12 (dry and wet) Standard. Color fastness to washing was conducted in agreement with the test method provided by ISO 105-C01 Standard. Color fastness to perspiration was conducted in agreement with the test method provided by ISO 105-E04 Standard. Color strength and dye absorption of the dyed sample were measured by K/S value. Results were shown in the Table 3 for the 4 types of dyestuff. Commercially, the dyestuffs of the best color fastness properties were recommended due to cheap price and availability.

2.7 FTIR test

FTIR experiments were carried out on four different dyed samples of cotton fabric to take the peak of infrared radiation. The clamp of the FTIR machine was unlocked to clamp the dyed samples. Infrared radiation (IR) was secreted through the dyed samples to identify the enhanced color fastness properties. Infrared radiation could pass through the sample fabric on the basis of the intensity of the color shade. Where the color intensity was higher, IR radiation showed a higher peaks at those points and vice versa. At the higher saturated region of color, the infrared radiation established higher peak weaves.

3 RESULTS AND DISCUSSION

<u>*Dye absorption and color measurement*</u>

For determining the color shade and dye absorption of dyed cotton fabrics the values of K/S were used. Results are shown in the Table 2 for the 4 types of dyestuff. Commercially, the dyestuffs of the best color fastness properties were recommended due to cheap price and availability.

Table 2 expressed the whole color shade of L*, a*, b*, c*, h* values and it specified that the higher values of L* expressed lighter shades and lower value of L* meant darker shades. The negative values of a* and b* denoted green and blue, where positive values of a* and b* denoted red and yellow. The highest K/S (3.97) values were obtained for henna/mehedy, where the lowest K/S (3.11) values were obtained for pomegranate color. It was also observed that, the highest K/S value had the lowest lightness values (L), which indicate the lightest color and vice versa. The highest K/S value with the lowest value of L, exhibit the best color fastness properties and vice versa.

Table 2 Values of K/S and values of CIE L* a* b* c* h* of dyed cotton fabric

Dyestuff	K/S	L	a*	b*	c*	h*
Henna/mehedy	3.97	42.91	0.33	1.27	1.29	83.83
Turmeric	3.68	55.89	2.21	3.63	4.05	81.99
Tea leaf	3.39	76.11	4.33	23.23	26.13	79.21
Pomegranate	3.11	79.11	4.69	25.77	27.18	77.39

<u>*Color fastness to light*</u>

It was seen from Table 3 that light fastness values (4-5) of the cotton fabric dyed with mehedy dye was the highest. Light fastness values (4) of the cotton fabric dyed with turmeric dye was the second. The 3rd and the 4th values of the color fastness properties of the cotton fabric dyed with tea leaf were (3-4) and pomegranate was (3).

<u>*Color fastness to wash*</u>

It was seen from Table 3 that wash fastness values (4-5) of the cotton fabric dyed with mehedy dye was the highest. Wash fastness values (4) of the cotton fabric dyed with turmeric dye was the second. The 3rd and the 4th values of the color fastness properties of the cotton fabric dyed with tea leaf were (3-4) and pomegranate was (3).

<u>*Color fastness to rubbing*</u>

It was seen from Table 3 that rubbing fastness values (dry 4, wet 3-4) of the cotton fabric dyed with mehedy dye was the highest. Rubbing fastness values (dry 4, wet 3-4) of the cotton fabric dyed with turmeric dye was the second. The 3rd and the 4th values of the color fastness properties were for the cotton fabric dyed with tea leaf (dry 3, wet 2-3) and pomegranate (dry 3, wet 2-3) dye.

Table 3 Color fastness values of the cotton samples

Cotton fabric dyed with	Light fastness	Wash fastness	Rubbing fastness		Perspiration fastness	
			Dry	Wet	Acidic	Alkaline
Henna/mehedy	4-5	4-5	4	3-4	4-5	4-5
Turmeric	4	4	4	3-4	4-5	4-5
Tea leaf	3-4	3-4	3	2-3	4	4
Pomegranate	3	3	3	2-3	3-4	3-4

<u>*Color fastness to perspiration*</u>

It was seen from Table 3 that perspiration fastness values (acidic 4-5, alkaline 4-5) of the cotton fabric dyed with mehedy dye was the highest. Perspiration fastness values (acidic 4-5, alkaline 4-5) of the cotton fabric dyed with turmeric dye was the same as turmeric dye. The perspiration fastness values of the cotton fabric dyed with tea leaf dye was 4 for acidic and 4 for alkaline. The 4th values of the color fastness properties were for the cotton fabric dyed with pomegranate dye was 3-4 both for acidic and alkaline medium.

FTIR observation

The colorfastness properties and the color intensity properties of the cotton fabrics were assessed using Fourier Transform Infrared spectroscopy. IR spectroscopy was taken after dyeing the fabric with natural selected dyestuffs. FTIR spectral observation was effortlessly detected the intensity of the color using IR spectrum with the facilities of a FTIR instrument and shown in Figures 6-9. The infrared rays can enter a few microns into the sample surface and shown the results with infrared radiation wave numbers. When the sample cannot grip infrared light a spectral scan was not achieved. IR radiation was used to detect the peaks connected to the sample from the spectral scan and then assessment of the enduring spectral scan was completed. The region of the infrared spectral was from 340 to 4600 wave numbers in the FTIR observation.

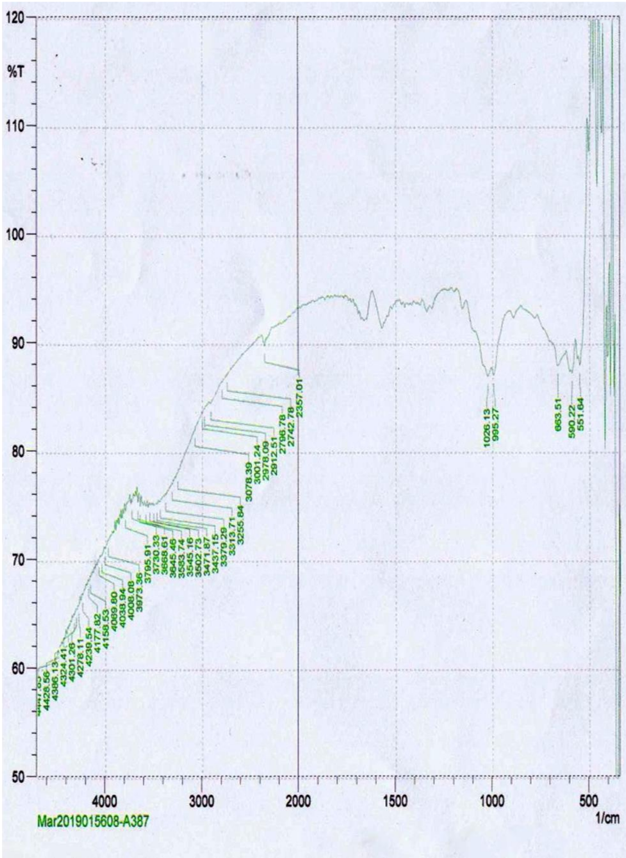
FTIR assessment of the anonymous materials was investigated using IR radiation with the IR highest peak points.

The lowest and highest peaks for the fabrics dyed with mehedy/henna were 362 cm^{-1} and 4609 cm^{-1} wave numbers. The lowest and highest peaks for the fabrics dyed with turmeric were 343 cm^{-1} and 4582 cm^{-1} wave numbers. The lowest and highest peaks for the fabrics dyed with tea were 405 cm^{-1} and 3541 cm^{-1} wave numbers. The lowest and highest peaks for the fabrics dyed with pomegranate were 516 cm^{-1} and 3363 cm^{-1} wave numbers. These peaks clarify the existence of the colorant in the perceptible spectral range and they were distinctive for detecting the chromophore present in the dyestuff those was responsible for specific colored shades on fabric.

The highest peak for the most intense color mehedy/henna was at 4609 cm^{-1} that confirms the existence of chromophore in fabric that increases dye fastness. That was why, the highest color fastness properties were obtained correspondingly in mehedy/henna dye stuffs (4609 cm^{-1}), then in turmeric dye stuffs (4582 cm^{-1}), then in tea leaf dye stuffs (3541 cm^{-1}) and finally in pomegranate dye stuffs (3363 cm^{-1}) that is shown in Table 4.

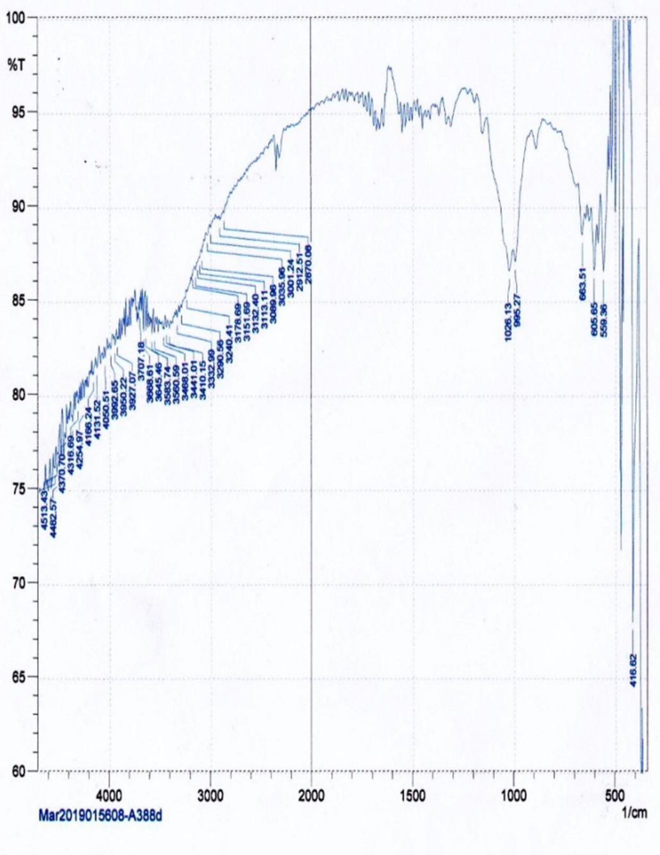
Table 4 FTIR highest wave numbers obtained from dyed cotton fabrics using different dyes

S.N	Fabric dyed with	Highest peak points (wave numbers) [cm^{-1}]
01	Henna/mehedy dye	4609
02	Turmeric dye	4582
03	Tea leaf dye	3541
04	Pomegranate dye	3363



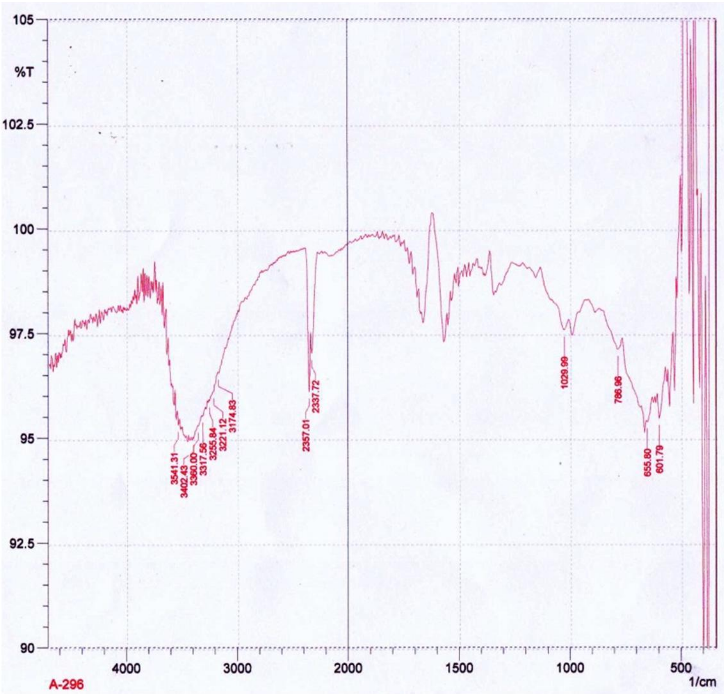
	Peak	Intensity	Corr. Inte	Base (H)	Base (L)	Area	Corr. Are
1	362.62	21.19	67.97	370.33	339.47	8.8	6.51
2	551.64	88.13	2.75	555.5	513.07	0.94	0.99
3	590.22	87.44	2.73	621.08	574.79	2.49	0.38
4	663.51	88.13	1.79	698.23	621.08	3.89	0.3
5	995.27	87.2	1.38	1006.84	918.12	3.79	0.12
6	1026.13	87.08	1.49	1138	1010.7	5.84	0.52
7	2357.01	89.95	0.73	2384.02	2345.44	1.71	0.08
8	2742.78	87.21	0.04	2746.63	2465.03	14.42	0
9	2796.78	86.6	0.08	2800.64	2754.35	2.82	0.01
10	2912.51	84.62	0.3	2924.09	2804.5	8.11	0.09
11	2978.09	84.13	0.06	2981.95	2931.8	3.68	0
12	3001.24	83.8	0.09	3005.1	2985.81	1.47	0.01
13	3078.39	82.15	0.08	3082.25	3005.1	6.23	0.01
14	3255.84	78.22	0.09	3259.7	3086.11	16.67	0.04
15	3313.71	77.22	0.09	3317.56	3263.56	5.93	0.02
16	3379.29	76.2	0.1	3383.14	3317.56	7.55	0.02
17	3437.15	75.57	0.2	3448.72	3402.43	5.56	0.02
18	3471.87	75.34	0.16	3479.58	3452.58	3.3	0.01
19	3502.73	75.22	0.23	3510.45	3483.44	3.32	0.02
20	3545.16	75.28	0.21	3549.02	3529.73	2.37	0.01
21	3583.74	75.12	0.51	3599.17	3572.17	3.32	0.04
22	3645.46	75.16	1.06	3653.18	3633.89	2.34	0.07
23	3668.61	75.47	1.23	3676.32	3657.04	2.3	0.06
24	3730.33	75.51	0.52	3738.05	3714.9	2.79	0.04
25	3795.91	74.68	0.87	3803.63	3753.48	6.14	0.12
26	3973.36	72.02	0.11	3977.22	3950.22	3.81	0.01
27	4008.08	71.28	0.21	4015.79	3992.65	3.38	0.02
28	4038.94	70.58	0.19	4042.8	4015.79	4.02	0.02
29	4069.8	70.2	0.11	4073.66	4062.09	1.76	0
30	4158.53	68.65	0.14	4162.38	4139.24	3.74	0.01
31	4177.82	68.27	0.16	4181.67	4162.38	3.18	0.02
32	4239.54	67.01	0.19	4243.4	4204.82	6.61	0.04
33	4278.11	66.02	0.2	4281.97	4266.54	2.75	0.01
34	4301.26	65.59	0.15	4305.12	4285.83	3.51	0.02
35	4324.41	65.15	0.18	4328.26	4308.97	3.56	0.01
36	4386.13	63.86	0.22	4389.99	4362.98	5.19	0.02
37	4428.56	62.95	0.19	4432.42	4413.13	3.84	0.03
38	4447.85	62.48	0.32	4455.56	4432.42	4.69	0.02
39	4548.15	60.39	0.13	4552.01	4490.28	13.26	0.11
40	4567.44	59.66	0.25	4571.29	4552.01	4.27	0.02
41	4609.87	58.73	0.28	4613.73	4594.44	4.39	0.02

Figure 6 FTIR observation of the henna/mehedy dyed fabrics



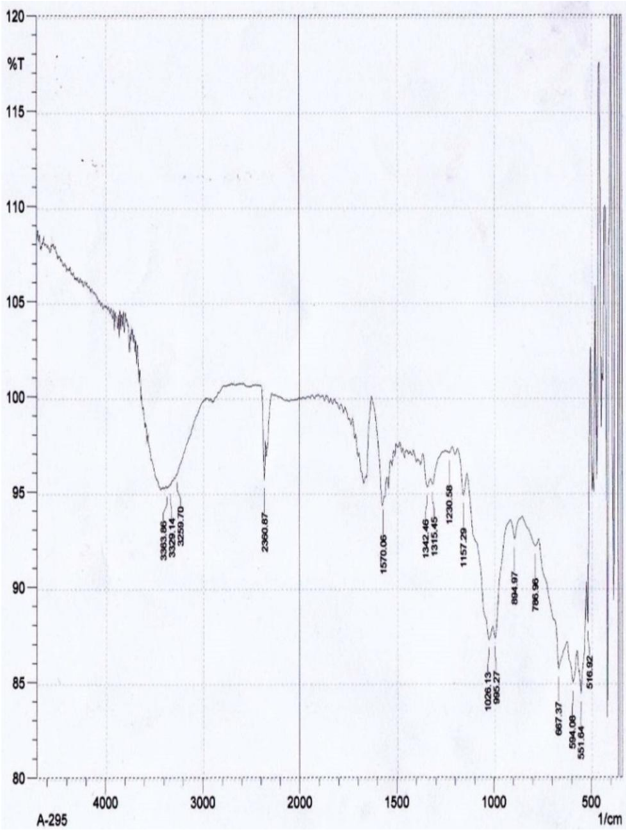
	Peak	Intensity	Corr. Inte	Base (H)	Base (L)	Area	Corr. Are
1	343.33	24	15.24	347.19	339.47	4.7	0.71
2	358.76	12.02	40.61	366.48	351.04	8.3	4.06
3	416.62	68.06	27.01	424.34	389.62	3.36	2.05
4	559.36	86.62	4.32	570.93	540.07	1.59	0.38
5	605.65	86.71	2.68	617.22	594.08	1.29	0.16
6	663.51	88.6	1.5	682.8	655.8	1.31	0.11
7	995.27	87.18	1.6	1006.84	933.55	3.12	0.15
8	1026.13	86.68	1.94	1134.14	1010.7	5.69	0.69
9	2870.08	89.78	0.22	2877.79	2831.5	2.08	0.02
10	2912.51	89.4	0.25	2916.37	2877.79	1.84	0.03
11	3001.24	89.04	0.2	3008.95	2970.38	1.9	0.02
12	3035.96	88.6	0.22	3047.53	3012.81	1.79	0.02
13	3089.96	87.67	0.27	3097.68	3070.68	1.5	0.02
14	3113.11	87.4	0.1	3116.97	3101.54	0.89	0
15	3132.4	87.16	0.06	3136.25	3120.82	0.91	0
16	3151.69	86.75	0.28	3163.26	3140.11	1.41	0.02
17	3178.69	86.44	0.11	3182.55	3167.12	0.95	0
18	3240.41	85.57	0.18	3244.27	3201.83	2.81	0.03
19	3290.56	84.75	0.21	3298.28	3259.7	2.71	0.01
20	3332.99	84.23	0.47	3340.71	3317.56	1.7	0.03
21	3410.15	83.62	0.41	3425.58	3402.43	1.77	0.02
22	3441.01	83.7	0.5	3452.58	3429.43	1.77	0.04
23	3468.01	83.59	0.57	3483.44	3456.44	2.07	0.05
24	3560.59	83.4	1.11	3568.31	3549.02	1.48	0.06
25	3583.74	83.34	1.16	3599.17	3572.17	2.04	0.07
26	3645.46	83.54	2	3653.18	3633.89	1.41	0.1
27	3668.61	83.47	1.93	3676.32	3657.04	1.41	0.09
28	3707.18	84.63	0.56	3714.9	3695.61	1.36	0.03
29	3927.07	83.08	0.71	3934.78	3907.78	2.14	0.08
30	3950.22	82.75	0.6	3961.79	3938.64	1.87	0.04
31	3992.65	82.58	0.48	4004.22	3977.22	2.2	0.04
32	4050.51	82.08	0.71	4058.23	4027.37	2.58	0.07
33	4131.52	81.55	0.76	4143.1	4108.38	3	0.09
34	4166.24	81.18	0.7	4177.82	4146.95	2.74	0.07
35	4254.97	79.95	0.85	4266.54	4247.25	1.83	0.04
36	4316.69	79.65	0.6	4324.41	4305.12	1.89	0.04
37	4370.7	78.67	0.55	4374.55	4355.27	1.95	0.04
38	4482.57	76.31	2.74	4494.14	4474.85	2.14	0.17
39	4513.43	76.73	0.62	4517.29	4498	2.13	0.04
40	4544.29	76.22	0.92	4559.72	4536.58	2.69	0.08
41	4582.87	75.14	1.56	4590.58	4563.58	3.26	0.15

Figure 7 FTIR observation of the turmeric dyed fabrics



	Peak	Intensity	Corr. Inte	Base (H)	Base (L)	Area	Corr. Are
1	405.05	89.68	10.41	412.77	393.48	0.54	0.51
2	601.79	95.5	0.74	609.51	574.79	0.61	0.07
3	655.8	95.42	0.12	659.66	636.51	0.45	0.01
4	786.96	97.15	0.35	852.54	771.53	0.9	0.08
5	1029.99	97.62	0.37	1083.99	1010.7	0.66	0.05
6	2337.72	97.07	0.73	2345.44	2283.72	0.48	0.09
7	2357.01	96.15	1.61	2391.73	2349.3	0.42	0.12
8	3174.83	96.6	0.1	3182.55	3116.97	0.91	0.02
9	3221.12	96.15	0.04	3224.98	3182.55	0.67	0
10	3255.84	95.94	0.06	3263.56	3228.84	0.61	0
11	3317.56	95.58	0.04	3321.42	3298.28	0.45	0
12	3360	95.33	0.03	3363.86	3332.99	0.63	0.01
13	3402.43	95.04	0.05	3406.29	3367.71	0.83	0
14	3541.31	95.35	0.26	3549.02	3529.73	0.39	0.01

Figure 8 FTIR observation of the tea leaf dyed fabrics



	Peak	Intensity	Corr. Inte	Base (H)	Base (L)	Area	Corr. Are
1	516.92	88.09	6.57	524.64	505.35	0.59	0.31
2	551.64	84.39	2.09	559.36	528.5	2	0.22
3	594.08	84.94	1.86	621.08	574.79	3.09	0.24
4	667.37	85.66	3.04	767.67	624.94	7.6	0.85
5	786.96	92.14	0.55	852.54	771.53	2.65	0.11
6	894.97	92.52	1.02	914.26	856.39	1.77	0.1
7	995.27	87.3	1.05	1002.98	918.12	3.49	0.09
8	1026.13	87.23	1.87	1138	1006.84	5.56	0.64
9	1157.29	94.8	1.52	1184.29	1141.86	0.79	0.12
10	1230.58	97.03	0.2	1246.02	1215.15	0.39	0.02
11	1315.45	95.38	0.44	1323.17	1265.3	0.94	0.03
12	1342.46	95.26	0.96	1361.74	1327.03	0.67	0.09
13	1570.06	94.44	0.62	1627.92	1566.2	0.79	0.08
14	2360.87	95.64	2.74	2399.45	2349.3	0.4	0.21
15	3259.7	95.9	0.06	3263.56	3109.25	1.97	0.02
16	3329.14	95.36	0.06	3332.99	3309.85	0.47	0
17	3363.86	95.2	0.11	3371.57	3336.85	0.73	0.01

Figure 9 FTIR observation of the pomegranate dyed fabrics

4 CONCLUSION

It was seen throughout the research that mehedy/henna dye exposed the best colorfastness properties in all the experiments. This was because mehedy/henna dye reacted with cellulose of cotton in alkaline condition to form a covalent bond that formed a long lasting attachment between the dye and the cellulose; therefore it was not removed by frequent treatment with steaming water in neutral conditions and exposed excellent color fastness properties. Mehedy dye contained a reactive group that acted as an integral part of fiber and that covalent bond was formed between the dye molecules and the terminal reactive group. Mehedy was dyed in two phases, one was dye absorption and second was fixation where reaction occurred between fiber and dye stuffs. Electro negativity of oxygen atom had lead propensity of OH group for ionizing. Cellulose was therefore ionized in alkaline conditions and acted as a nucleophilic component which, showed succeeding reactions with acid halides. Mehedy dyes required alkaline catalyst for fixation with cellulose that was why mehedy dyestuff showed best color fastness properties those were ascertained by above experiments. This research was practice based and further study could enhance the possibilities of dyeing cotton fabrics with natural dyes.

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