Effectsof natural and synthetic mordants on dyeing of Jute/Cotton yarn with Sustainable Allium Cepa

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Abstract

The coloration of juton yarn, which itself is constructed of 65% jute and 35% cotton, is achieved by using the abundant and sustainable onion peel extracted dye. The red onion skin is extracted using the Soxhlet method. Guava leaves (extraction by immersion method) and potash alum (aqueous solution) were used to fix the natural dyes into the fibers. The coloring was wiped out by three mordanting processes (Pre, Post and meta mordanting). The dyed samples were tested and evaluated for color fastness (i.e., laundering and rubbing) and parameters of colorimetry (CIE lab and K/s values) and the determination of the functional group; transmittance is done through FTIR. The colorfastness properties of alum mordant are better than guava mordant; for both rubbing and laundering. Yarn dyed using alum mordant shows higher shade depth as well as color values. The FTIR graph does not represent any significant change in bond formation on cellulosic fiber. Hence, the eco-friendly common color extracted from the waste onion peel and potash alum mordant can be an alluring choice for passing on the juton yarn with different exquisite shades.

Keywords: *Jute cotton blended yarn, Onion Skins, Natural Dye, Sustainable, Mordant.*

1.Introduction

Plants are the main sources of natural dyes owing to their availability. Natural dyes are sustainable, hygenic and renewable (Hossain *et al.*, 2021). Jute is obtained from the bark of jute plant. The main component of jute is cellulose (58-63%) and hemicellulose (20-24%) and lignin (12-15%) and some other constituents are such as fat, pectin etc.The natural source used in the present study is onion peel because it is a beneficial and available source of natural dye. Recently there has been growing interest in the use of natural dyes in textile applications. This is a result of the stringent environmental standards imposed by many countries in a response to the toxic and allergic reactions associated with synthetic dyes. Natural dyes exhibit better biodegradability and are generally more compatible with the environment (Desai, H T Deo* and B K, 1999). There are many natural sources for dyeing, for this research onion peel has been chosen; it is rich in tannin, gives bright color, is cost-effective, is good for the environment and has many other advantages. Onion peel dyeing does not harm the environment (Seema, 2017). There have already been studies of using onion peel dyes along with mordants on leather (Ersin ÖNEM, Mehmet Mete MUTLU, Sevinç GÜNAY, Hande AZERİ, 2012) (K Amutha, S Grace Annapooran, 2018) (Shahin Hossain, M. A., 2021) (Uddin, Mohammad Gias, 2014). For a bright pink dye and color; red onions were preferable. Red onions contain anthocyanins (Gertrude Maud Robinsion and

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Robert Robinson, 1932) Mordants are used because of the inferior fastness properties natural dyes possess. Mordants can chelate several dye molecules together to create a larger complex and provide a link between the dye and fiber. These complexes help the fiber retain color, thus increasing the depth of shade and fastness to wet and mechanical treatments (Gordon, P. F., & Gregory, P. , (1983)). For a comparative study a natural mordant and a synthetic mordant have been used; guava leaves (psidiumguajava) and Alum Rock respectively.

Guava leaves contain tannins which give great substantivity to cellulose, and Alum creates large complexes; giving good fastness to wet. The soxhlet method was adapted for the extraction of dye from onion skin. The conventional Soxhlet method was applied (Mandana Bimakr, Russly Abdul Rahmana, Farah Saleena Taipa, Ali Ganjloo , 2011). Tannin has to be extracted from the guava leaf for that maceration to be done.

2. Materials and Methodology

Materials

The material used in the whole research was jute cotton blended yarn which was a mix of Jute yarn of 65% and 35% cotton. This blended yarn was collected from Bangladesh Jute Research Institute (BJRI). Dyes such as Red Onion peel (Allium Cepa) were collected from the local market which was located at Uttara, Dhaka. For natural mordant, we collected Fresh Guava Leaves (Psidium guajava L.) from Uttara, Dhaka and synthetic mordant Alum (Potash alum) was collected from the local market Uttara, Dhaka, Bangladesh.

Methods

Extraction of dye from onion peel

Onion dye was extracted by the Soxhlet extraction method. This method has a long extraction time and consumption of large amounts of solvents said D. Grigonis and used this method widely due to its simplicity (D. Grigonisa, 2005).The Onion skins are taken and dried under the sunlight and grinded in a small unit by the grinding machine. Finally, weight is taken after removing the wastage by using a fine strainer. The founded onion peel was 350g after drying, crushing and straining. Aqueous extraction was used to extract the color component from onion skin. This process was done under pH 5. The crushed onion skins were boiled at 60 minutes with an M:L ratio of 1:10 (where onion skin weight was taken in grams and water in milliliters). Finally, the mixture was cooled down and the dye extracts were filtered precisely (Uddin, Mohammad Gias, 2014).

Extraction of mordants

For extraction of Tannin, Maceration is done by the material being soaked in a mixture of organic solvents ethanol. Ethanol contains both polar and non-polar groups which make it able to extract both polar and non-polar compounds, it also eliminates the production of chemical waste. This method is easy and simple (Cheong, 2005). About 40 grams of guava leaves were taken and dried under the sunlight for 48 hours then grinded in a grinding machine to get a completely powdered form. Then that powered form was immersed in 140 ml of ethanol with an M:L ratio of 1:10 and then that solution was kept for 24 hours. Then filter the solution using a nylon filter cloth then the solution was boiled so that the ethanol will get evaporated leaving only the tannin and then cooled for next use (Meigy Nelce Mailoa, , JANUARY 2014).

Scouring & Bleaching

The raw jute cotton blended yarn was treated in a solution of wetting agent and sequestering agent (1g/L& 2g/L) and a solution of caustic soda (2g/L). Then the yarn is treated with 35% hydrogen peroxide (1.65 ml/L) solution for bleaching, then wash with 1 g/L detergent and maintaining a material-to-liquor ratio of 1:10 at pH 11 and temperature 98°C for 1 hour.

Mordanting

Mordanting was done on Jute cotton blended yarn whereas it's a chemical binding agent it adheres well to both the yarn and dye. This research has used Guava leaves as a natural mordant and Alum as a synthetic mordant so that they form a coordination complex with the dye. The mordanting and dyeing process was done in three processes, Pre mordanting, Meta mordanting and Post mordanting, and the liquor ratio is obtained (1:20) for 60 minutes at 60°C. A lower temperature was chosen on a higher temperature may degrade the dye and fabric, a lower temperature is preferable for natural dyes (Desai, H T Deo* and B K, 1999). In pre-mordanting, the substrate is treated with the mordant first and then dye. In Meta mordanting, the mordant and dye are mixed in the dye bath. In post-mordanting, the dyeing is done first, then the dyed material is treated with a mordant.

Natural and Synthetic mordanting processes:

Pre mordanting

The first weight of the sample is taken, then tannin and alum as natural and synthetic mordant are taken with water, then put into the chemical bath chamber. Then the sample is taken out from the chamberand dried then dye added with 10%, 20% and 30% shade percentages is taken and made solution with water then put into the chemical bath chamber again. Then taken out, rinsed and dried (K Amutha, S Grace Annapooran, 2018).

Meta mordanting

First weight of the sample is taken, then both tannin and alum are taken and dye added with 10%, 20% and 30% shade percentages are taken with water and then put into the chemical bath chamber. Then taken out, rinsed and dried (K Amutha, S Grace Annapooran, 2018).

Post mordanting

First weight of the sample is taken, then dye added with 10%, 20% and 30% shade percentages is taken and made solution with water then put into the chemical bath chamber then taken out from the chamber and dried. Then tannin and alum are taken with water then put into the chemical bath chamber. Then taken out, rinsed and dried (K Amutha, S Grace Annapooran, 2018).

Mesurement and Analysis

Color Yield Mesurment

Dyed textile samples were analyzed by measuring the reflectance curve between 360 and 700 nm with the reflectance Premier Colorscan SS5100H spectrophotometer. The relation between the spectral (R) of the sample, its light absorption (K) and its scattering characteristic (Zubairu, Abdu, 2015).

$$\frac{K}{S} = \frac{(1-R)2}{2R}$$

The color coordinates values are analyzed by the CIELab system whereas the values for L*, a*, b*, c* and h* were calculated.L*, a*, b*c* and h* represent lightness, redness-greenness of color, yellowness-blueness of color, saturation of color and hue angle, respectively.(Uddin, Mohammad Gias, 2014).

Color Fastness

The rubbing Fastness test was carried out in ISO 105-X12 method and the Wash Fastness test was carried out in ISO 105-2CS 2002 method.(Uddin, Mohammad Gias, 2014).

FTIR Analysis

The FTIR was analyzed using Shimadzu FTIR-8400s from Bangladesh University of Engineering & Technology. The IR spectroscopy was measured for bands at 4000-500 cm^{-1}

3. Result and discussion

Fastness Results

Fastness is the resistance of color to fading and staining. After dyeing, the result might meet certain challenges, so for this, colorfastness is observed by ISO method. As there has been only one kind of dye used, however, different kinds of mordants were chosen, e.g. Tannin extracted from Guava leaves as the natural mordant and Alum made into aqueous solution as the synthetic mordants. ISO 105 was adapted to find which mordant gave better fastness properties, also to find which mordanting method was better as well, i.e., Pre mordanting, Meta mordanting and Post mordanting, and which shade percentage of the dye was better 10%, 20% and 30%. Colorfastness to laundering (Staining) is done which is shown in **Table.1**, for Guava mordant and **Table.2**, for Alum mordant.

Table.1: Colorfastness to laundering(Staining): Guava Mordant

Name of Samples	Rating
Pre mordanting 10%	3
Pre mordanting 20%	3
Pre mordanting 30%	3/4
Meta mordanting 10%	2/3
Meta mordanting 20%	3
Meta mordanting 30%	3
Post mordanting 10%	3
Post mordanting 20%	3/4
Post mordanting 30%	3

Table.2: Colorfastness to laundering(Staining): Alum mordant

Name of Samples	Rating
Pre mordanting 10%	3
Pre mordanting 20%	3/4
Pre mordanting 30%	4
Meta mordanting 10%	3
Meta mordanting 20%	2
Meta mordanting 30%	3
Post mordanting 10%	3
Post mordanting 20%	4
Post mordanting 30%	3

From the comparison carried out in **Table.1** and **Table.2** which is the staining rating, we see using Alum mordant gave better fastness properties ranging from 2 to 4 than using Guava mordant which ranged from 2 to 3/4. In Table.1 and 2, in which the Pre-mordanting 30% has better ratings than the other two mordanting processes which ranged from 3/4 to 4.

In **Table.3** and **Table.4**, it is shown the color's fastness to fading, it so happens that after laundering using ISO 105, the color bleeds and the color lightens. In **Table.3** and **Table.4**, it is seen by the ratings that color has changed to almost no color in the pre-mordanting 30%. By the comparison seen in **Table.1** and **Table.2**, although Alum mordant has less staining, it is seen Guava mordant lightened less with the ratings from 1 to 3 shown in **Table.3** than Alum mordant did show in **Table.4** with the ratings ranging from 1 to 2.

Table.3: Colorfastness to laundering (Fading): Guava mordant

Name of Samples	Rating
Pre mordant 10%	1
Pre mordant 20%	2/3
Pre mordant30%	1
Meta mordant 10%	2
Meta mordant 20%	2/3
Meta mordant 30%	1/2
Post mordant 10%	2
Post mordant 20%	1
Post mordant 30%	3

Table.4: Colorfastness to laundering(Fading): Alum mordant

Name of Samples	Rating
Pre mordant 10%	1/2
Pre mordant 20%	1/2
Pre mordant 30%	1
Meta mordant 10%	1/2
Meta mordant 20%	2/3
Meta mordant 30%	1/2
Post mordant 10%	1/2
Post mordant 20%	2
Post mordant 30%	2

In **Table.5** and **Table.6** color fastness to rubbing is shown. Every textile fades when it is rubbed, in ISO 105, it is determined how much color is faded due to rubbing, it is done once using a dry cloth and second using a wet cloth. We see in both Table.5 and Table.6 that using dry cloth color didn’t fade at all with the ratings of 4/5 to 5 which is very good to excellent, but using the wet cloth a lot of colors bled which is shown below:

Table.5: Color fastness to rubbing: Alum mordant

Sample Name	ISO-105 DRY	ISO-105 WET
Premordant 10%	4/5	4
Premordant 20%	5	4/5
Pre mordant 30%	5	4
Metamordant 10%	5	4
Metamordant 20%	5	3
Metamordant 30%	5	4/5
Postmordant 10%	5	4/5
Postmordant 20%	5	5
Postmordant 30%	5	4/5

Table.6: Color fastness to rubbing: Guava mordant

Sample Name	ISO-105 DRY	ISO-105 WET
Premordant 10%	5	3/4
Premordant 20%	5	4/5
Premordant 30%	5	4/5
Meta mordant 10%	5	4/5
Meta mordant 20%	5	3
Meta mordant 30%	5	4/5
Post mordant 10%	5	4/5
Post mordant 20%	5	4
Post mordant 30%	5	4/5

In **Table.5**, when seeing colorfastness using wet cloth; where Alum mordant is used; Post mordanting gave better fastness, shade 20% gave a better fastness rating of 5 than shade 10% and 30% which is rated at 4/5. Shade 20% in Pre mordanting gave a better fastness rating of 4/5 and shade 10% and 30% gave poorer fastness, rating 4. Meta mordanting gave the poorest fastness compared to the other processes; shade 20% gave the poorer fastness, rating 3 than shade 10% and 30% rated 4 and 4/5 respectively.

In **Table.6**, Post mordanting gave better fastness; shade 20% gave a poorer fastness rating of 4 than shade 10% and 30% which is rated at 4/5. Shade 10% in Pre mordanting gave a poorer fastness rating of 3/4 and shade 20% and 30% gave better fastness, rating 4/5. Meta mordanting gave the poorest fastness compared to the other processes, shade 20% gave the poorer fastness, rating 3 than shade 10% and 30% rated 4/5.

Considering the comparison between Alum mordant and Guava mordant, it is safe to safe to say, Alum mordant gave better fastness properties using a wet cloth than Guava mordant, when using a dry cloth Alum mordant had a poorer fastness than Guava mordant.

Table.7: color coordinates values of dyed juton yarn

Mordant type	K/S value at λmax	CV% of K/S value	Color coordinates				
			L^*	a^*	b^*	c^*	h^*
Onion dyed yarn	5.26	77.5	10.960	19.360	22.247	60.461	10.960
Pre N (10%)	4.348	70.5	56.079	11.008	13.385	17.330	50.545
Pre N (20%)	3.028	67.3	59.936	10.464	11.369	15.452	47.355
Pre N (30%)	3.525	67.7	57.164	9.628	13.308	16.426	54.093
Meta N (10%)	3.109	69.3	60.780	7.494	11.459	13.692	56.793
Meta N (20%)	3.305	57.4	55.351	6.621	16.954	18.201	68.640
Meta N (30%)	3.623	66.5	57.667	7.207	11.292	13.396	57.429
Post N (10%)	2.117	68.8	65.467	7.414	12.174	14.254	58.635
Post N (20%)	3.612	70.0	58.306	6.754	19.101	20.260	70.498
Post N (30%)	3.424	72.2	59.818	10.591	11.668	15.758	47.751
Pre S (10%)	2.752	62.9	55.852	3.910	21.598	21.949	79.707
Pre S (20%)	2.943	74.0	59.754	6.280	26.100	26.845	76.440
Pre S (30%)	3.375	78.4	61.469	7.621	27.184	28.232	74.309
Meta S (10%)	2.558	72.4	61.286	4.909	24.963	25.441	78.843
Meta S (20%)	3.053	77.5	63.382	7.389	27.529	28.503	74.945
Meta S (30%)	3.177	75.2	61.971	6.616	26.221	27.043	75.808
Post S (10%)	2.207	60.0	60.956	5.738	17.525	18.440	71.842
Post S (20%)	2.757	74.0	61.672	7.285	22.150	23.317	71.765
Post S (30%)	2.804	74.9	59.768	6.529	25.620	26.439	75.673

[N.B: Pre N- Pre mordanting with Guava leaf, Meta N- Meta mordanting with Guava leaf, Post N- Post mordanting with Guava leaf, Pre S- Pre mordanting with Potash alum, Meta S- Meta mordanting with Potash alum, Post S- Post mordanting with Potash alum]

The color Yield of dyed yarns is shown in **Table 7.** In the mordanting method, mordant resulted in an improved color yield of the dyed yarns. The value of (K/S = 3.375) which is Pre S 30% which showed a 78.4% value of CV% has the most color variation and high strength. Then Meta S 20% > Meta S 30% > post S 30%, that is color yield gradually decreased and The value of (K/S= 3.305) which is Meta N 20% which showed 57.4% value of CV% has the uniform color and low strength was found.

Effects of Mordanting on the color characteristic of dyed yarn are shown in **Table 7.** The positive value of L* is 65.4 which is Post N 10% indicating that its color is lighter than the reference samples. The positive value of a* is 11.008 which is Pre N 10% indicating that its color is reddish or less green than the reference samples. The positive value of b* is 27.5 which is Meta S 20% indicates that its color is yellowish or less blue than the reference samples. The positive value of c* is 28.5 which is Meta S 20% indicating that its color is brighter than the reference samples.

FTIR Results

Figure 1 displays the FTIR spectrum for yarn made of jute and cotton that has been mordanted with potash alum, guava leaf extract, and unmordanted control yarn. Islam et al hold that practically all of the absorption bands found in FTIR spectra, such as those around 3425 cm^{-1}, are caused by hydroxyl stretching, which may be caused by hydroxyl bonds found in cellulose, lignin, tannins, or phenolic compounds, in particular, 2900 cm^{-1}, 1600 cm^{-1}, 1100 cm^{-1},1050 cm^{-1} and so on (Islam *et al.*, 2022). As a result, only the amplitude of various peaks changed in this finding, with no discernible change in FTIR spectra. These might be attributable to the particular way various mordants interact with the dyed fabric.

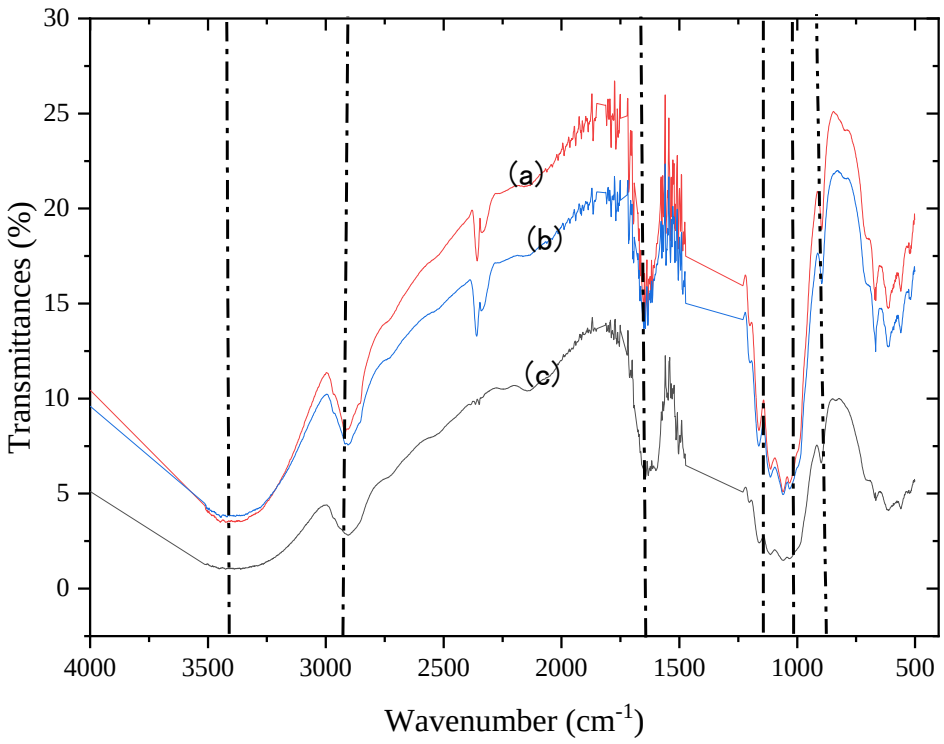

Figure 1: FTIR spectra of (a) Alum Mordanted (b) Guava mordanted (c) Unmordanted dyed yarn

4. Conclusion

Onion peels are wastes that end up in landfills. These wastes could be sustainably employed to color textile substrates. The color yield and fastness qualities of pre-mordanted yarns were higher. The outcomes of the mordanted yarn, in particular the yarns mordanted with potash alum, improved in terms of wash fastness and color strength. Therefore, potash alum and onion peel waste can both be used on a large scale in the dyeing industry for environmental sustainability.

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