RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

This chapter deals with the results of the various testing procedures conducted and the inferences thereof. The results have been given and discussed under the following subsections:

4.1 Colour palette and reflectance spectrophotometer data obtained through selected dye and composite mixtures with metal mordants, pH variation and natural mordants.

4.2 Eco-parameters of the selected metal mordanted dyed samples.

4.3 Optical density and percent transmission of spent dye-bath of the experimental variables.

4.4 Fastness test of selected dye and composite mixture on Sisal and Eri silk fabric.

4.5 Value addition of minor fibres/fabrics through natural dyes and designing of products for home décor.

4.6 Exhibition of the natural dyed home decor products, consumer responses and statistical analysis.

4.1 Colour palette and reflectance spectrophotometer data obtained through selected dye and composite mixtures with metal mordants, pH variation and natural mordants

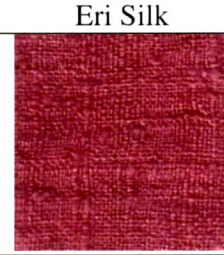
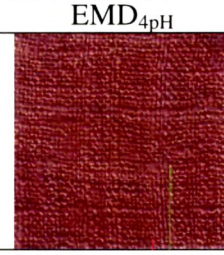
One of the major objectives of the research was to develop a varied colour palette by different permutation combinations of the selected dye with the mordants. The research proposed to explore tannins from tea and pomegranate rind for their suitability of use as mordants. It was also proposed to vary the pH of the dye liquor during application in order to obtain variation in the colour yield. A gamut of one hundred and eighty shades was obtained; ninety shades on each substrate. The shade card obtained as a result of the exploration of the various dye fibre and mordant

combinations has been given in Plate - 4.1 to 4.9 and the reflectance spectrophotometeric data of the dyed samples has been discussed below.

A spectrophotometer measures the intensity of light in a part of the spectrum especially transmitted or emitted by particular substances. Light reflecting from the dyed substrates was measured using a Premier 5100 Spectrophotometer. A spectrophotometer works on the principle of measurement of the ratio of spectral radiant flux reflected from a light-diffusing specimen to that reflected from a light-diffusing standard substituted for the specimen. DL*, Da*, Db*, and k/s values were taken into consideration to analyze the results of the spectrophotometric analysis of the dyed samples.

4.1.1. Colour palette and reflectance spectrophotometric analysis of Eri and Sisal samples dyed with Madder dye.

Munjistin an anthraquinone colourant present in the roots of *munjeet* (rubia cordifolia), was amongst the oldest dyes sources discovered by dyers. Roots of madder contain not only munjistin but also a very large range of yellow to red colourants, mostly anthraquinones in the free or glycosidic states.[10] Hence, madder offered a large range of distinctly different shades of dyes with respect to the mordants it is combined with. The range of colours it produced was from light pink, light red violet, red, orange, brown to dark brown and maroon.

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}

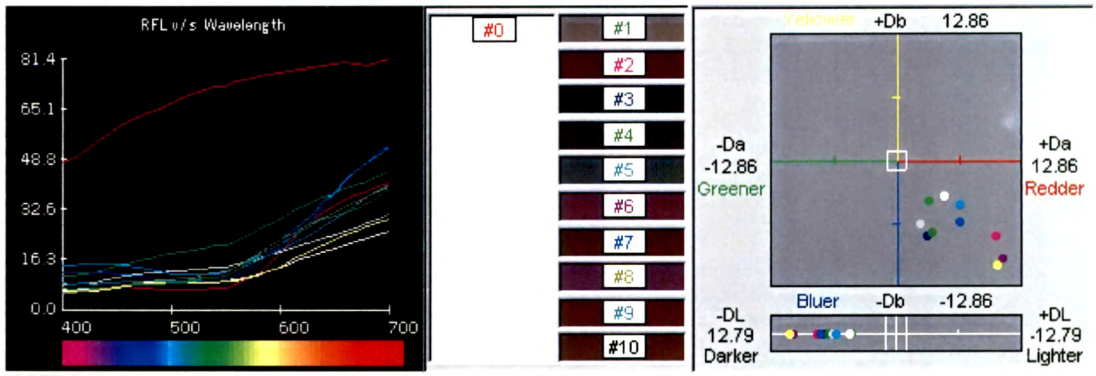
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.1: Colour palette of Madder dye on Eri silk and Sisal fibre for variables under study.

Table 4.1 a: Reflectance values of Madder dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	$EMD_{4\ pH}$	$EMD_{6\ pH}$	$EMD_{8\ pH}$	EMTD	EMPRD
DL*	—	-4.535	-8.032	-7.384	-7.005	-6.562	-10.44	-7.657	-10.78	-6.151	-4.755
Da*	—	3.226	10.20	3.087	3.700	2.375	10.86	6.391	10.38	6.425	4.946
Db*	—	-4.109	-7.710	-7.641	-7.332	-6.528	-10.40	-6.306	-10.74	-4.491	-3.691
Dc*	—	3.364	0.697	-6.494	-5.869	-5.917	-0.728	-3.238	-1.306	-1.937	-2.185
k/s		9.65	10.51	11.12	12.18	13.63	10.42	4.94	3.58	9.81	4.40

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



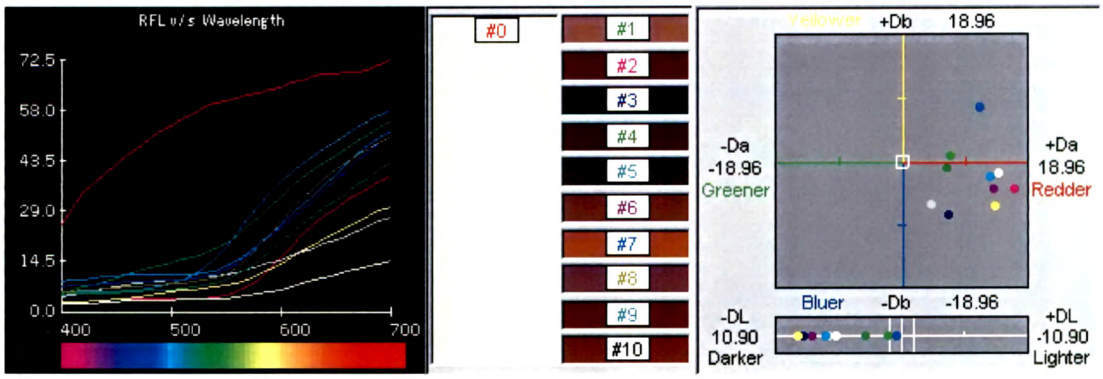
Graph 4.1a: Reflectance values of Madder dye on Eri silk fabric.

It was observed from the Table 4.1a, that the DL* values of all the samples show a negative reading. Hence it was interpreted that the samples scored low in terms of luminance and the samples were dark. This was also supported by the fact that the k/s values of all the samples had a score from 3.58 to 12.18. It was hence averred that the samples obtained a dark shade due to dyeing with madder dye. The darkest of the sample was the one premordanted with ferrous sulphate. The Da* and Db* values indicates that the colour obtained ranged in between red and blue with samples mordanted with chromium, iron and dyed at acidic pH showed the darkest values.

Table 4.1 b: Reflectance values of Madder dye on Sisal Fibre.

	Control	SD	SMAD	SMCuD	SMCrD	SMFeD	SMD_4 pH	SMD_6 pH	SMD_8 pH	SMTD	SMPRD
DL*	—	-1.187	-6.343	-8.556	-3.208	-6.293	-7.770	-0.475	-8.8.9	-6.519	-5.723
Da*	—	7.317	16.96	6.936	6.616	4.366	13.65	11.51	14.12	13.18	14.63
Db*	—	0.841	-4.067	-7.971	-0.893	-6.381	-4.028	8.255	-6.613	-2.129	-1.791
Dc*	—	2.219	4.024	-5.776	-.349	-5.581	1.588	10.68	0.217	2.671	3.910
k/s	0.640	5.990	15.74	19.50	16.31	8.160	5.370	7.850	4.320	8.650	7.113

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

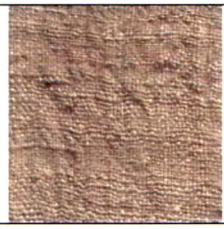
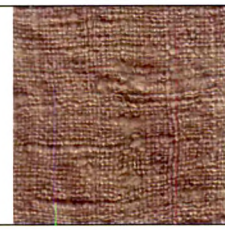
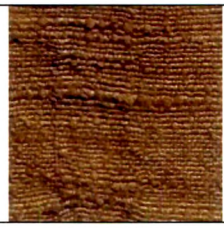
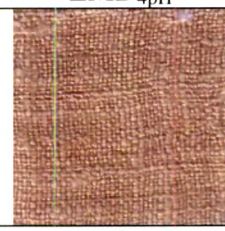
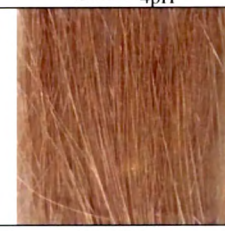
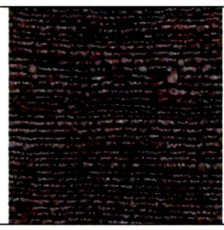
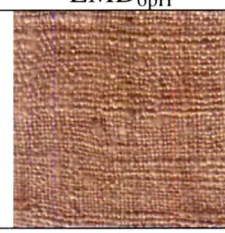
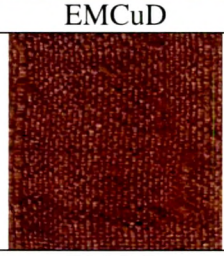
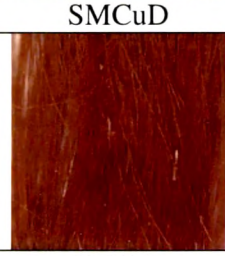
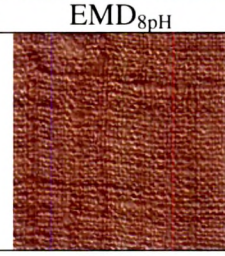
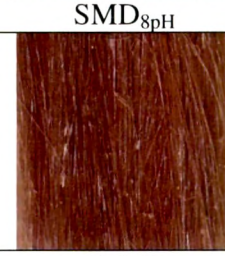
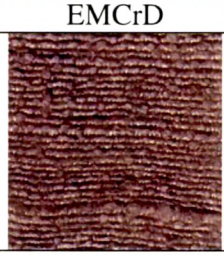
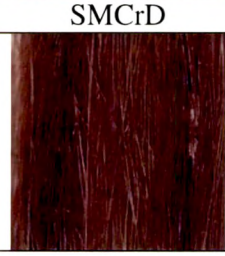
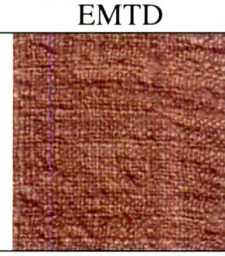
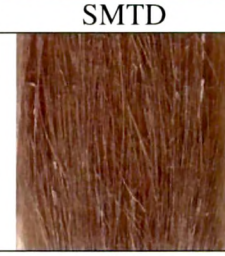


Graph 4.1b: Reflectance values of Madder dye on Sisal fibre.

Table 4.1b displays data regarding the reflectance values obtained from the spectrophotometric analysis of Sisal fibre samples dyed with madder dye. It was observed from the table that all the Da* values are positive and Db* values except for the samples pretreated with Harda and the sample dyed at 4pH. Similarly, when the DL* values of these two samples are compared they indicate a proximity towards lightness or luminance with very minor negative readings. Hence it could be also said that these two samples tended towards being yellow and the sample dyed at 4pH had a more yellowish brown colour compared to the myrobolan treated dyed sample. The positive Da* values indicated that the Sisal samples had a redder tone compared to the red brown tone obtained by the Eri silk samples.

4.1.2. Colour palette and reflectance spectrophotometric analysis of Eri and Sisal samples dyed with marigold dye

Marigold dye produces yellow to orange-red colourants that are soluble in oils. There are 400 carotenoids that have been identified so far. They are unsaturated molecules consisting of a long chromophore of several conjugated double bonds, which gives them their light absorbing and colouring properties. The absorption of the dye is aided by the mordant but it also has an interesting property to oxidize on contact with air like a vat dye and hence produces a greenish brown colour.[10] Hence, the range of colours obtained on dyeing of Eri silk and Sisal fibre with marigold dyes ranged from Khaki brown, olive green, beige, to slate and dark greenish brown.

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

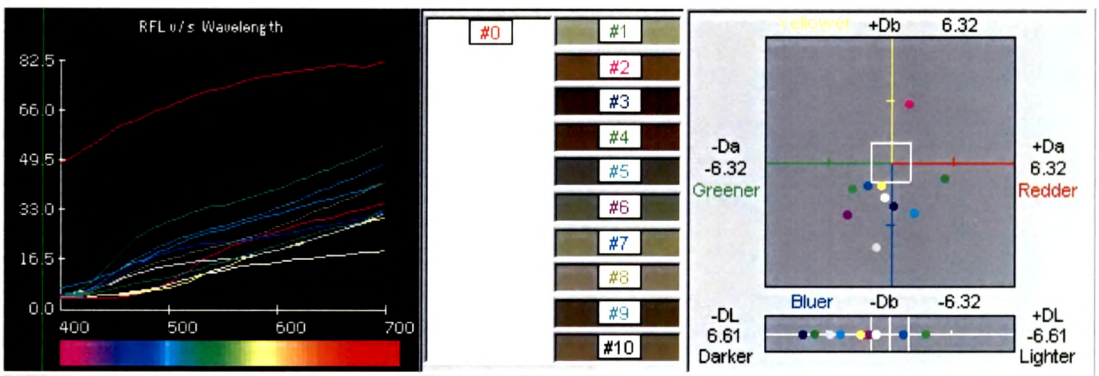
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.2: Colour palette of Marigold dye on Eri silk and Sisal fibre for variables under study.

Table 4.2a: Reflectance values of Marigold dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	EMD_4 pH	EMD_6 pH	EMD_8 pH	EMTD	EMPRD
DL*	—	1.942	-1.285	-4.612	-3.985	-3.143	-1.052	0.765	-1.51	-2.671	0.721
Da*	—	-1.932	0.916	-0.117	2.717	-0.722	-2.220	-1.173	-0.495	1.187	0.347
Db*	—	-1.383	3.002	-2.214	-0.863	-4.323	-2.626	-1.195	-1.214	-2.548	-1.741
Dc*	—	-1.328	3.067	-2.201	-0.382	-4.341	-2.519	-1.202	-1.231	-2.388	-1.785
k/s	0.390	8.354	14.58	15.64	14.53	10.25	11.11	14.26	11.53	12.58	8.52

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



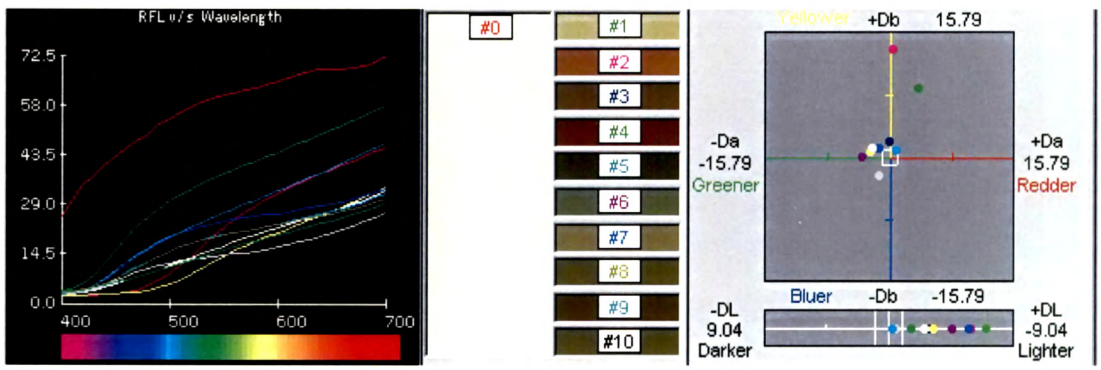
Graph 4.2a: Reflectance values of Marigold dye on Eri silk fabric.

The visual inspection of the samples dyed with marigold dye indicated that the samples obtained an olive green colour upon air drying. This was also supported by the Graph 4.2a generated from the spectrophotometer software. It indicated that six out of ten samples obtained a negative Da* reading and sample pretreated with pomegranate rind falling on the blue axis between red and green. Sample treated with potassium dichromate showed reddish tendency and the one treated with alum appeared yellower. The darkest sample amongst the lot was the one dyed after copper sulphate pretreatment.

Table 4.2 b: Reflectance values of Marigold dye on Sisal fibres

	Control	SD	SMA D	SMCu D	SMCr D	SMFe D	$SMD_{4\ pH}$	$SMD_{6p\ H}$	$SMD_{8\ pH}$	SMT D	SMP RD
DL*	—	7.041	5.895	2.999	1.672	0.535	4.546	5.826	3.246	0.227	2.555
Da*	—	-2.326	0.341	-0.010	3.603	-1.469	-3.485	-1.475	-2.456	0.748	-2.351
Db*	—	1.185	13.78	1.985	8.900	-2.367	0.124	1.278	0.807	0.955	1.200
Dc*	—	1.339	13.79	1.985	9.136	-2.288	0.482	1.342	0.982	0.967	1.386
k/s	0.620	7.380	19.76	15.16	18.50	13.18	11.54	11.69	12.27	11.42	11.23

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.2b: Reflectance values of Marigold dye on Sisal fibre

According to Graph 4.2b most of the samples indicated a clustering effect near the green yellow base of the axis, barring sample pretreated with myrobolan and potassium dichromate. This was indicative of the fact that the samples showed a khakhi brown colour compared the greenness of olive for the rest of the samples. The positive DL* values indicated lightness and the highest k/s value was attained by sample pretreated with potassium dichromate. Negative Da* values also indicated that the samples were greener.

It is worth noting here that the substrate plays an important role. Eri silk samples dyed in marigold obtained colour ranging form reddish brown to green. Whereas, leaving an exception of two samples all the sample of Sisal fibre obtained a beautiful Olive green ranging from dark to light depending on the interference from the mordants they were pretreated with.

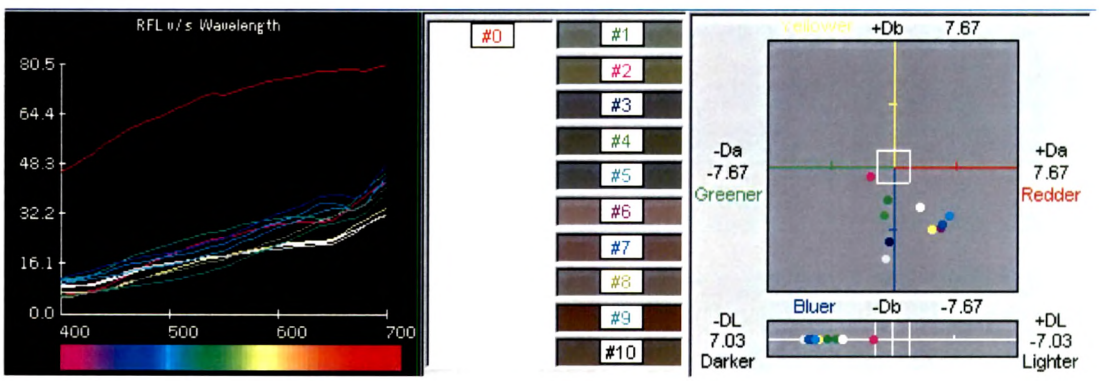
4.1.3. Colour palette and reflectance spectrophotometric analysis of Eri and Sisal samples dyed with henna dye

A native plant of western India, henna has spread both east and west and has been cultivated in most of the tropical and subtropical regions of the world. Henna is one of the rare examples of dye-plant with an ancient history and has wide application even today. The dye produced a range of colours from grey to brown to light fawn and burnt sienna and brown.

Table 4.3 a: Reflectance values of Henna dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	$EMD_{4\ pH}$	$EMD_{6\ pH}$	$EMD_{8\ pH}$	EMTD	EMPRD
DL*	—	-3.145	-1.011	-4.580	-3.637	-5.031	-4.315	-4.723	-4.164	-4.314	-2.786
Da*	—	-0.625	-1.387	-0.282	-0.324	-0.444	2.890	2.993	2.373	3.479	1.654
Db*	—	-3.042	-0.558	-4.647	-2.080	-5.673	-3.796	-3.569	-3.828	-3.053	-2.421
Dc*	—	-3.053	-0.538	-4.654	-2.089	-5.684	-3.153	-2.904	-3.362	-2.241	-2.258
k/s	0.390	4.740	7.49	10.60	11.35	8.498	9.13	12.26	11.72	9.31	5.58

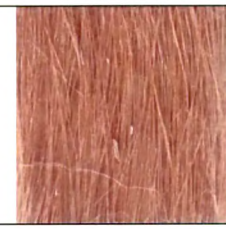
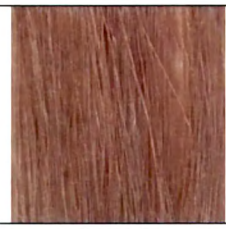
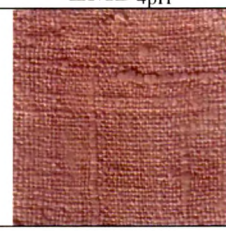
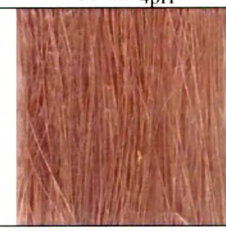
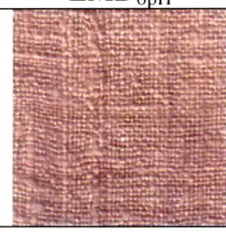
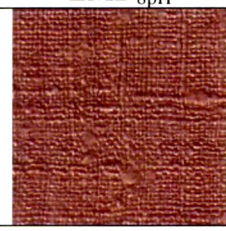
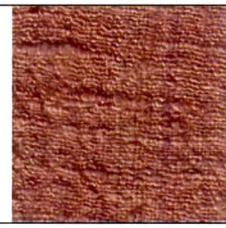
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.3a: Reflectance values of Henna dye on Eri silk fabric.

All the Eri silk samples dyed with Henna dye fall on the negative DL* axis indicating that the samples were dyed in a dark shade. It is noticed from the table 4.3a that the Da* values of the first five samples are borderline negative indicating a hint of green in the hue. The remaining set of samples were located in the positive Da* region between the red and blue quarter of the Graph 4.3a, which indicated that the

samples were reddish in colour. The colour obtained by dyeing with henna dye was a beautiful fawn with tonal variations according to each pretreatment.

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

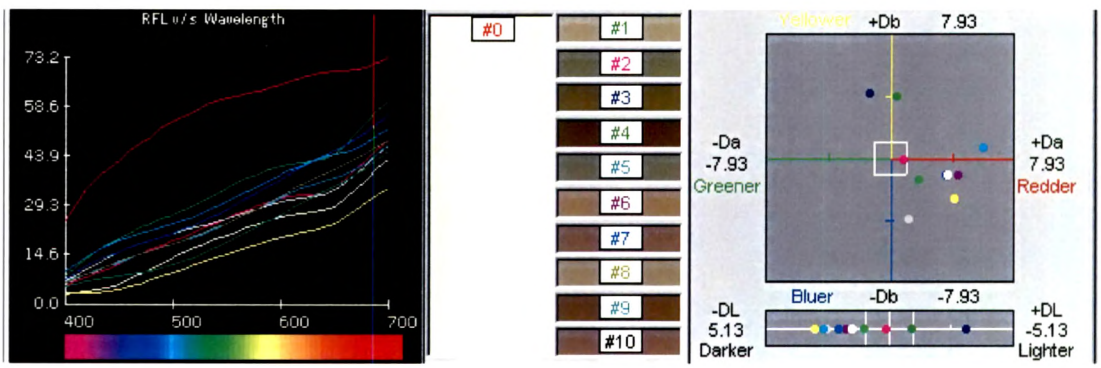
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.3: Colour palette of Henna dye on Eri silk and Sisal Fibre for variables under study

Table 4.3 b: Reflectance values of Henna dye on Sisal fibre.

	Control	SD	SMAD	SMCuD	SMCrD	SMFeD	SMD_4 pH	SMD_6 pH	SMD_8 pH	SMTD	SMPRD
DL*	—	1.025	0.152	-3.127	-0.942	2.580	2.112	1.799	3.107	-2.743	1.596
Da*	—	1.796	0.798	-1.357	0.411	1.160	4.335	3.531	4.069	5.931	3.632
Db*	—	-1.349	-0.022	4.247	3.978	-3.850	-1.007	-1.604	-2.603	0.684	-1.035
Dc*	—	-1.256	-0.006	4.292	3.981	-3.806	-0.468	-0.705	-2.709	1.599	-0.698
k/s	0.640	2.780	5.410	10.53	14.33	3.930	3.520	4.560	2.650	6.400	4.712

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.3b: Reflectance values of Henna dye on Sisal fibre.

The k/s values of all the samples of Sisal fibre compared with Eri silk samples dyed with Henna dye indicate that the Sisal fibre samples were lighter in hue compared to the Eri silk fabric samples. This again indicates that henna acts as an acid dye, exhibiting higher substantivity towards protein fibre compared to cellulose fibre. The DL* values from Table 4.3.b. indicate that samples pretreated with copper sulphate, potassium dichromate, and Tea were darker compared to the rest of the samples with their k/s values also indicative of the fact; which were 10.53, 14.33 and 6.40 respectively.

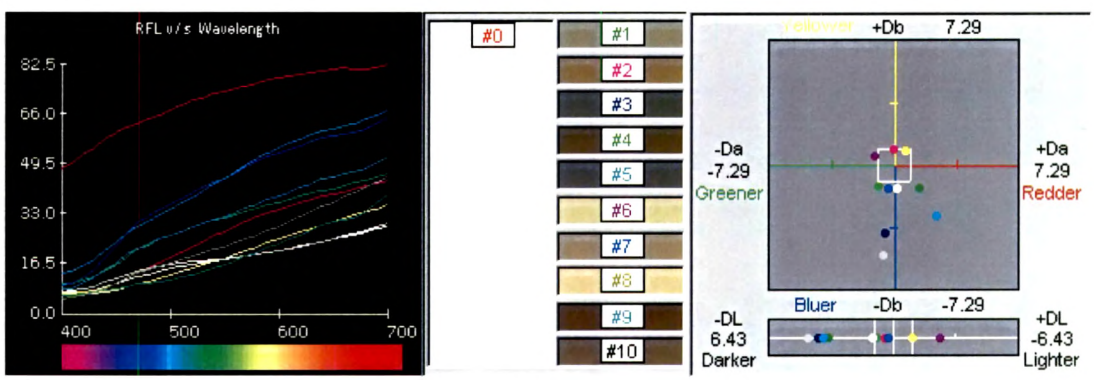
4.1.4. Colour palette and reflectance spectrophotometric analysis of eri and sisal samples dyed with flame of forest dye

The yellow dyes from the *palasha* flowers were mentioned in ancient Indian texts from the classical period (AD-300-700). The tree puts on a magnificient array of large flowers of a bright orange-red colour.[10] It was observed that inspite of the vibrant colours of the fresh flowers the colour was not retained when producing a colour palette. The shades produced by the dye were of pale yellow to muddy brown and dark brown colours.

Table 4.4 a: Reflectance values of Flame of Forest dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	EMD_4 pH	EMD_6 pH	EMD_8 pH	EMTD	EMPRD
DL*	—	-0.908	-0.443	-3.892	-3.335	-4.431	2.349	-0.249	0.992	-3.642	-1.031
Da*	—	-0.929	-0.002	-0.571	1.412	-0.661	-1.130	-0.338	0.614	2.491	0.173
Db*	—	-1.300	0.995	-3.960	-1.340	-5.289	0.528	-1.314	0.886	-2.928	-1.397
Dc*	—	-1.325	0.993	-3.983	-1.139	-5.314	0.507	-1.330	0.937	-2.373	-1.382
k/s	0.400	4.366	11.51	13.65	14.12	13.18	8.8	8.45	7.03	7.72	8.51

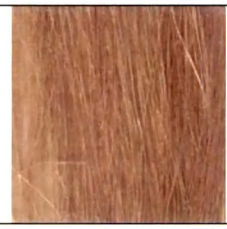
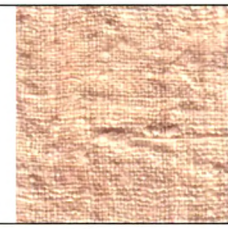
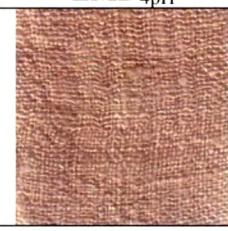
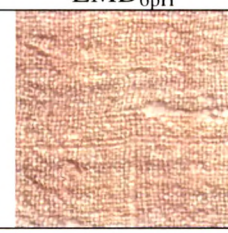
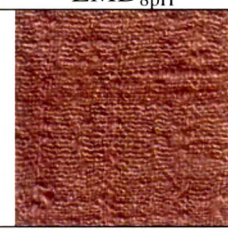
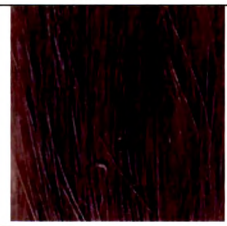
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.4a: Reflectance values of Flame of Forest dye on Eri Silk fabric.

From the table 4.4a it was observed that samples treated with alum, ferrous sulphate and alkaline pH, similar DL* values and the plot of these also indicated that their co-ordinates align on the negative DL* axis as seen in the Graph 4.4a. Hence, it was maintained that the samples were dark. Eri silk samples pretreated with potassium dichromate, copper sulphate and ferrous sulphate had the highest k/s values

with and individual score of 14.12, 13.65 and 13.18 respectively. A look at the Da* and Db* axis indicate that the samples were located around the centre of the axis. This leads us to conclude that most of the colour was near the gray region of luminance and chromaticity.[26]

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

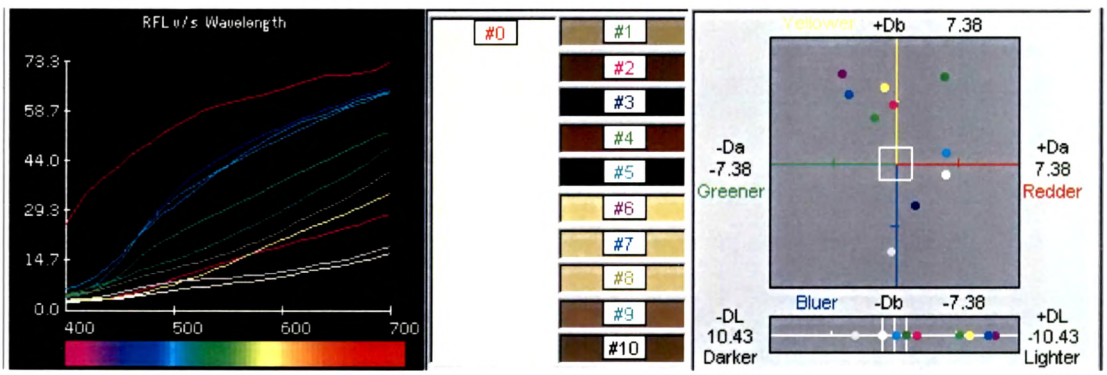
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.4: Colour palette of Flame of Forest dye on Eri silk and Sisal ibre for variables under study.

Table 4.4 b: Reflectance values of Flame of Forest dye on Sisal fibre.

	Control	SD	SMA D	SMCu D	SMCr D	SMFe D	SMD_4 pH	SMD_6 pH	SMD_8 pH	SMT D	SMPR D
DL*	—	5.498	1.828	-3.290	0.958	-3.286	8.430	7.845	6.231	0.100	-0.954
Da*	—	-1.242	-0.135	1.218	2.905	-0.271	-3.185	-2.762	-0.670	3.032	3.020
Db*	—	2.742	3.468	-2.513	5.171	-5.192	5.376	4.074	4.509	0.703	-0.614
Dc*	—	2.780	3.468	-2.465	5.354	-5.189	5.595	4.249	40519	0.950	-0.386
k/s	0.630	9.120	13.70	18.12	15.73	16.81	6.810	7.020	5.080	7.050	8.521

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.4b: Reflectance values of Flame of Forest dye on Sisal fibre.

It was interesting to note that Eri silk samples dyed with Flame of forest dye had a scatter diagram like appearance, with samples falling under three of the following zones: the red yellow, yellow green and blue red. Samples dyed at 4, 6, 8pH and myrobolan pretreated sample were under the yellow zone, some of the samples like copper sulphate ferrous sulphate pretreated were bordering red green region, Myrobolan treated sample was on the yellow axis and samples treated with alum and tea showed a clear burnt sienna colour. The darkest of the samples were how ever copper sulphate pretreated and ferrous sulphate pretreated with k/s values 18.12 and 16.81 respectively.

4.1.5. Colour palette and reflectance spectrophotometric analysis of eri and sisal samples dyed with Ratanjot dye

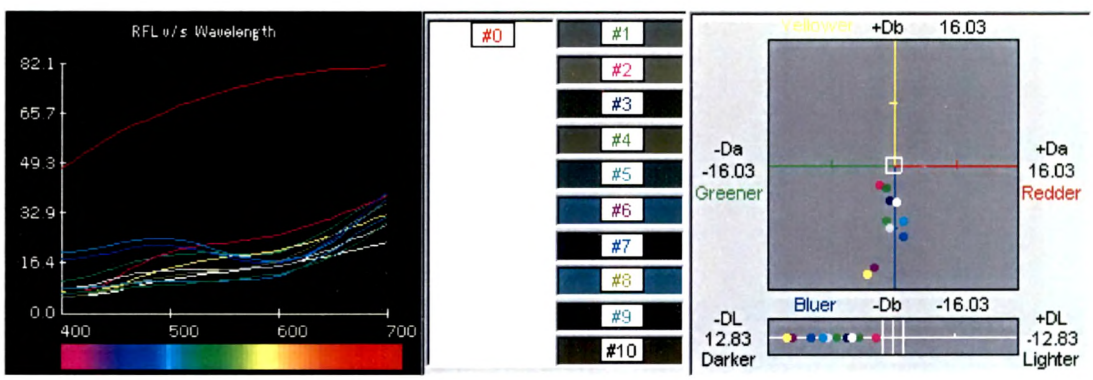
The chemical and technical literature mentioned this plant with roots yielding a violet dye and is mentioned in hindi as *ratanjot* meaning "ruby red". True to its name the dye develops beautiful blue purple and dark browns depending upon the

mordant it is dyed with. It was also worth noting that on variation with pH the dye obtains beautiful blue purple with the acidic pH and grayish blue with the alkaline pH. The dye has subtle variations in colour from grey brown to greenish brown and gery violets.

Table 4.5 a: Reflectance values of Ratanjot dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	EMD_{4pH}	EMD_{6pH}	EMD_{8pH}	EMTD	EMPRD
DL*	—	-5.717	-1.687	-4.740	-3.496	-6.666	-9.35	-8.498	-10.83	-7.145	-4.259
Da*	—	-1.060	-1.866	-.544	-0.938	-0.546	-2.467	1.299	-3.432	1.116	0.328
Db*	—	-7.125	-2.533	-4.539	-3.081	-8.032	-13.10	-9.277	-14.03	-7.203	-4.798
Dc*	—	-7.149	-2.503	-4.562	-3.109	-8.050	-9.972	-8.559	-8.641	-6.847	-4.721
k/s	0.410	5.368	8.048	11.58	10.91	7.114	5.31	1.82	5.25	8.77	1.49

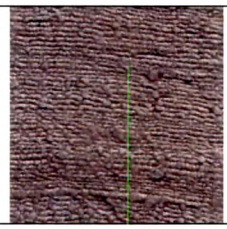
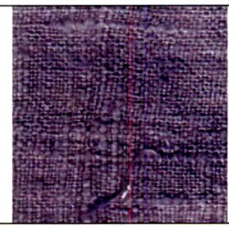
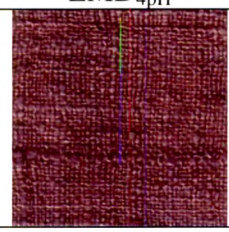
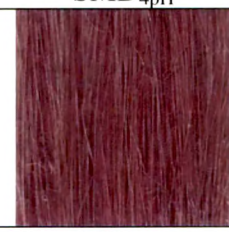
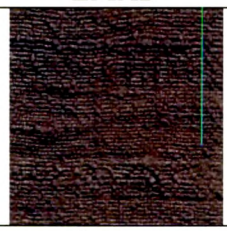
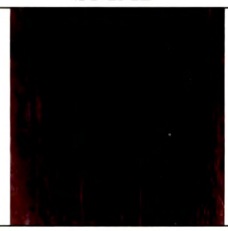
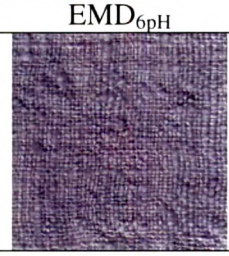
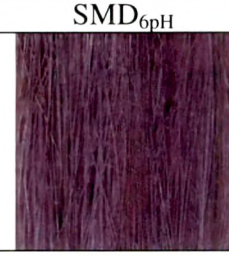
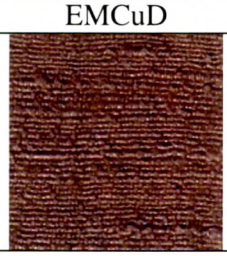
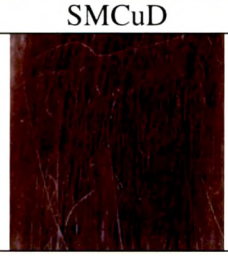
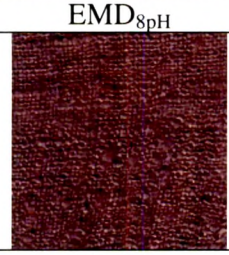
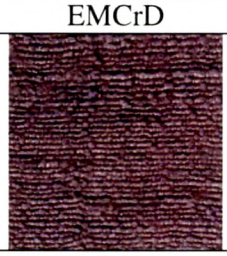
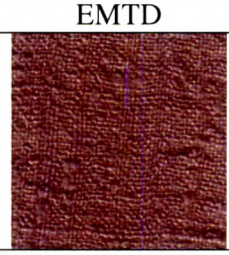
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.5a: Reflectance values of Ratanjot dye on Eri Silk.

It was indicated form the plot of readings of the DL* axis in Graph 4.5a that all the samples dyed with Ratanjot dye was on the –DL axis, concluding that all the samples were dark/dull in nature. Visual assessment of the samples however shows that the samples ranged from muted browns to beautiful grayish violet and purple. The Da* and Db* values of the samples indicate that all the sample barring the samples dyed with a variation of pH show a green brown tendency. The Da* and Db* reading of samples dyed with ratanjot at 4pH, 6pH and 8pH indicated that sample dyed at 4pH and 8pH were red with more amount of blue. At the same time the DL* values indicate that the sample dyed at 4pH was darker compared to the sample at

8pH. Hence, the spectrophotometric evaluation of the samples gave quantifiable data, which supported visual assessment of the dyed samples.

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

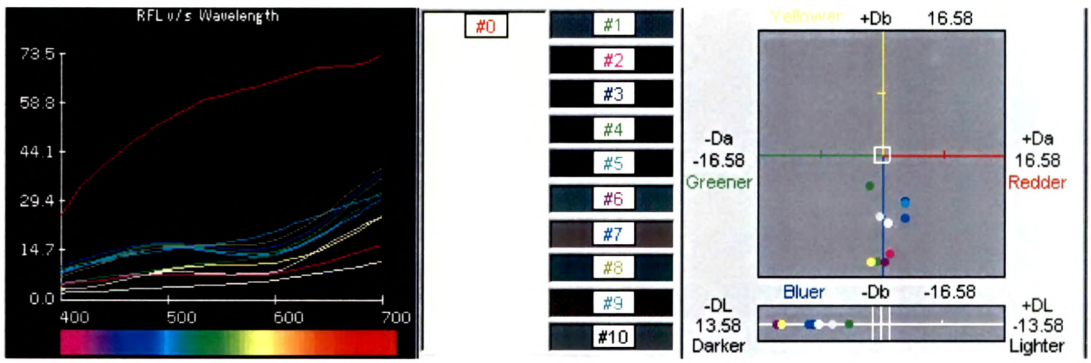
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.5: Colour palette of Ratanjot dye on Eri silk and Sisal fibre for variables under study.

Table 4.5 b: Reflectance values of Ratanjot dye on Sisal fibre

	Control	SD	SMA D	SMCu D	SMCr D	SMFe D	SMD_4 pH	SMD_6 pH	SMD_8 pH	SMT D	SMPR D
DL*	—	-11.16	-11.05	-7.511	-3.450	-5.368	-11.58	-8.048	-10.91	-7.114	-6.842
Da*	—	-0.660	0.952	2.974	-1.640	-0.307	0.411	3.131	-1.51	3.063	0.693
Db*	—	-14.56	-13.40	-6.37	-4.193	-8.354	-14.58	-8.564	-14.53	-6.536	-9.291
Dc*	—	-14.50	-13.29	-5.93	-4.098	-8.350	-14.55	-8.042	-14.21	-6.122	-9.235
k/s	0.630	3.670	8.750	20.70	12.88	13.51	3.240	4.010	4.000	7.610	4.736

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



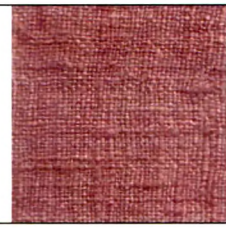
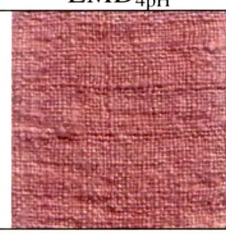
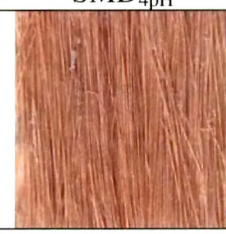
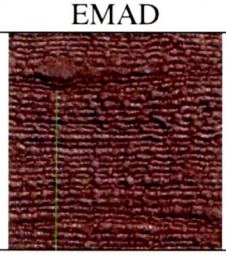
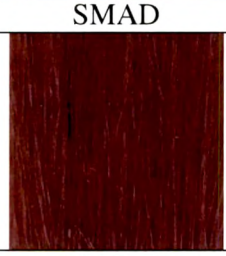
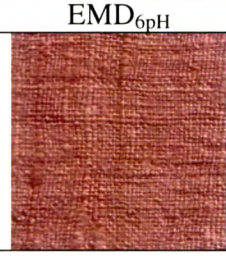
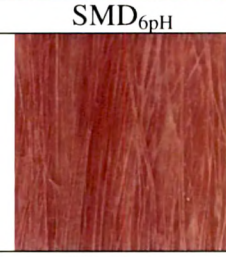
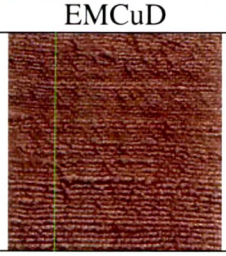
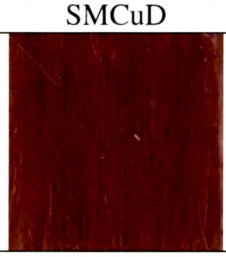
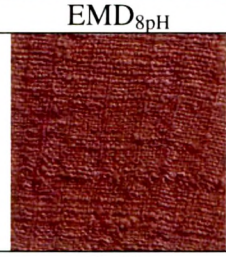
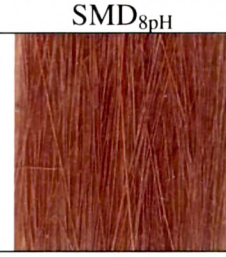
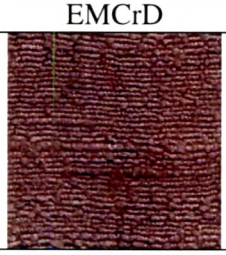
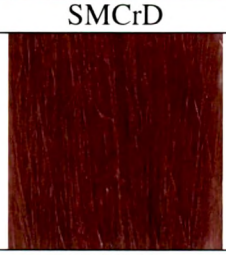
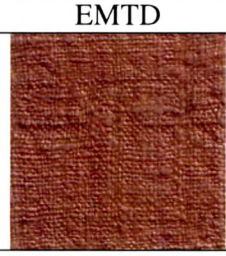
Graph 4.5b: Reflectance values of Ratanjot dye on Sisal fibre.

Negative DL* values from the table 4.23b, indicated that the colour obtained falls underneath the central grey plane seen in Graph 4.5b. Hence, it could be said that the colours obtained are dark. The Da* and Db* values indicated that the samples had coordinates that coincided with the –Db* axis and also located in the centre of the Da* axis indicating that the colour obtained was bluish grey in varying degrees of blue. k/s score of 20.70, 13.51 and 12.88 was obtained by samples pretreated with copper sulphate, ferrous sulphate and potassium dichromate respectively. The darkest sample of the lot was the sample pretreated with copper sulphate metal mordant.

4.1.6. Colour palette and reflectance spectrophotometric analysis of Eri and Sisal samples dyed with Catechu dye

In addition to the colourants of the flavonol group (including quercetin), catechu and cutch containes 55-60% tannins, derivatives of catechin (name originating from that of the tree). Addition of various mordants brought a certain

nuance to the shade.[10] The tones obtained covered almost the complete range of brown from hazel and dkhaki, through "wood" and "chamois" to almost black-browns like the colour of *katha(used as a chewing ingredient in paan).*

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

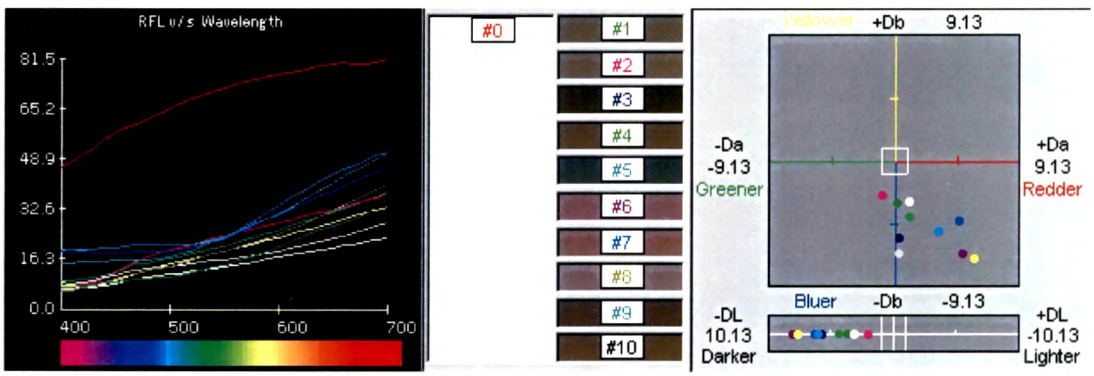
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.6: Colour palette of Acacia Catechu dye on Eri silk and Sisal fibre for variables under study

Table 4.6 a: Reflectance values of Acacia Catechu dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	EMD_4 pH	EMD_6 pH	EMD_8 pH	EMTD	EMPRD
DL*	—	-4.396	-2.070	-5.788	-3.749	6.222	-8.126	-6.371	-7.835	-6.049	-3.163
Da*	—	1.020	-0.979	0.296	0.149	0.345	4.940	4.695	5.889	3.259	1.087
Db*	—	-4.143	-2.470	-5.641	-3.030	-6.704	-6.748	-4.356	-7.127	-5.120	-2.932
Dc*	—	-3.950	-2.508	-5.565	-3.002	-6.597	-4.348	-2.650	-3.899	-4.055	-2.721
k/s	0.620	3.980	3.531	4.335	3.069	5.931	3.632	1.97	3.87	5.34	2.54

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



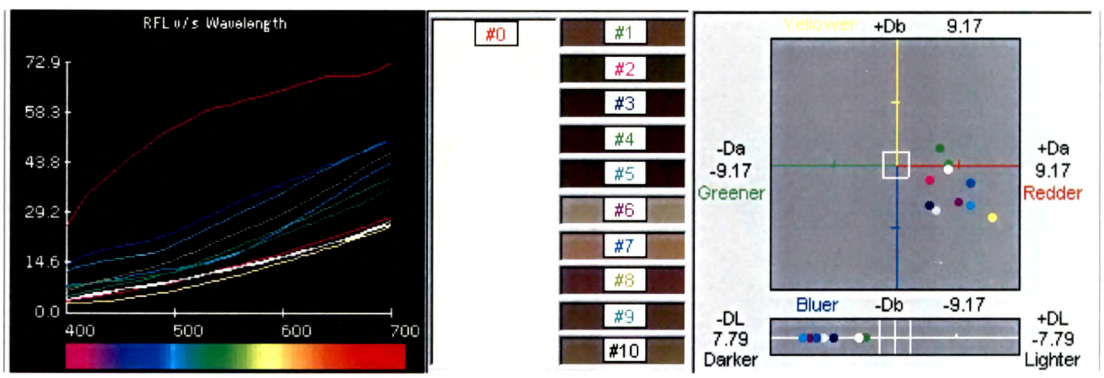
Graph 4.6a: Reflectance values of Acacia Catechu dye on Eri Silk.

Table 4.6a presents readings of Eri silk fabric dyed with Acacia Catechu dye. It was observed from the data that all the dyes showed –DL* values indicating that the dyed samples were dark in nature. The plot of Da* and Db* coordinates of the dye in Graph 4.6a indicates that the colour obtained from the dyeing experiments with Acacia Catechu dye was mostly in the red blue region of the graph. The appearance of the samples show that the colour obtained is a reddish brown to fawn. With some of the pretreatments yielding a dark hue like the samples pretreated with only myrobolan and the sample pretreated with tea and metal mordanted samples like copper sulphate and ferrous sulphate. The k/s readings of each of the above mentioned samples were 3.980, 5.34, 4.335, 3.069 respectively.

Table 4.6 b: Reflectance values of Acacia catechu dye on Sisal fibre.

	Control	SD	SMAD	SMCuD	SMCrD	SMFeD	$SMD_{4\ pH}$	$SMD_{6\ pH}$	$SMD_{8p\ H}$	SMTD	SMPRD
DL*	—	-1.998	-2.070	-3.807	-1.776	-4.427	-5.331	-4.863	-5.786	-5.782	-2.209
Da*	—	3.855	2.472	2.445	3.237	3.015	4.582	5.565	7.170	5.501	3.901
Db*	—	0.098	-1.082	-2.960	1.225	-3.410	-2.758	-1.302	-3.894	-2.980	-0.380
Dc*	—	0.514	0.897	-2.757	1.502	-3.093	-2.066	-0.378	-2.132	-1.979	0.107
k/s	0.630	3.160	10.84	9.140	10.58	8.810	2.050	2.640	4.890	5.120	5.096

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.6b: Reflectance values of Acacia Catechu dye on Sisal Fibre.

It was observed on visual inspection that amongst the samples pretreated with metal mordants the Sisal fibre samples appeared brighter in colour compared to the Eri silk samples. It was also observed that the Da* values of all the dyed samples was positive indicating that the samples had a reddish tone on them. The k/s values of the indicated that Acacia Catechu dye yielded pink to brown colours with good colour strength.

4.1.7. Colour palette and reflectance spectrophotometric analysis of eri and sisal samples dyed with Madder Ratanjot composite dye

Madder and Ratanjot were classified in the mordant/disperse class of dyes, both dyes hence had similar characteristics. The colours obtained through the composite dyeing of madder and ratanjot belonged to almost an average of the colour

contributed by the two colours. Beautiful range of red violet to violet to purple to dark brownish mauve were obtained as a result of the composite dyeing experiment.

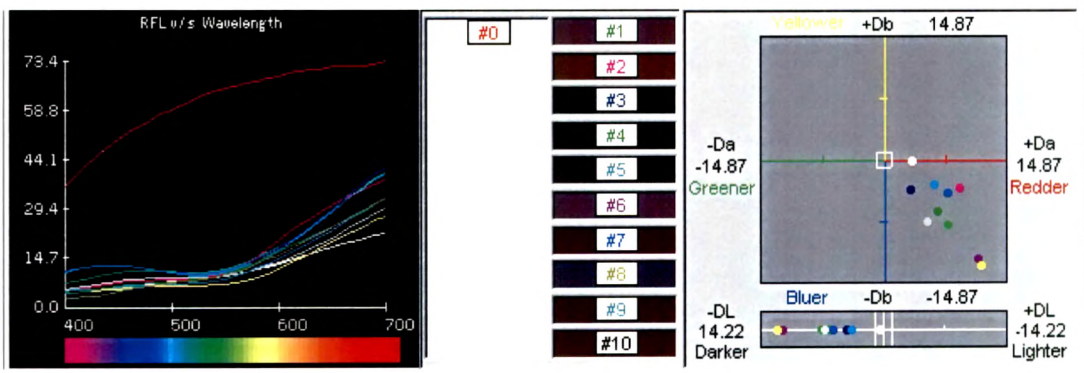
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.7: Colour palette of Madder and Ratanjot Composite dye on Eri silk and Sisal fibre for variables under study.

Table 4.7 a: Reflectance values of Madder and Ratanjot composite dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	EMD_4 pH	EMD_6 pH	EMD_8 pH	EMTD	EMPRD
DL*	—	-7.261	-4.314	-4.356	-6.401	-6.889	-5.925	-11.75	-12.22	-3.760	-0.381
Da*	—	7.617	9.045	3.278	6.481	5.308	7.721	11.43	11.85	6.127	3.331
Db*	—	-7.804	-3.390	-3.628	-6.217	-7.582	-3.960	-12.00	-12.87	-2.939	-0.114
Dc*	—	-3.886	0.170	-3.032	-3.647	-5.446	-1.140	-1.928	-1.608	-1.199	0.365
k/s	0.390	4.880	7.590	9.54	9.800	6.780	3.250	8.330	3.280	9.14	14.69

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



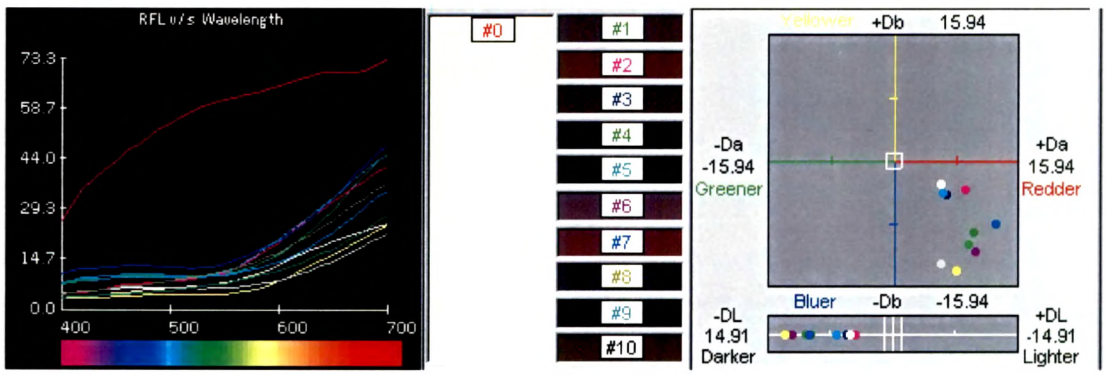
Graph 4.7a: Reflectance values of Madder and Ratanjot composite dye on Eri silk.

Visual inspection and observation from the plot and the values of DL* confirm that the dyed samples are dark in nature. Ratanjot imparts a distinctly grey colour to the substrate and bluish grey in case of dyeing at 6pH and 8 pH. As observed from the plot it is indicated by the spot exactly in the centre of the red blue region where it gives more of the appearance of grey mauve. In case of this dye mixture it is observed that all the shades fall under the red blue region; and they are lesser red and more concentrated towards the blue region. Hence, we may say that out of madder and Ratanjot dye mixture; Ratanjot dye imparts more colours compared to madder. The k/s values indicate that the sample pretreated with pomegranate rind exhibits the highest colour strength amongst all the samples.

Table 4.7 b: Reflectance values of Madder and Ratanjot composite dye on Sisal fibre

	Control	SD	SMAD	SMCuD	SMCrD	SMFeD	$SMD_{4\ pH}$	$SMD_{6p\ H}$	$SMD_{8\ pH}$	SMTD	SMPRD
DL*	—	-10.45	-4.452	-5.553	-9.718	-12.09	-12.01	-10.07	-12.91	-6.701	-5.101
Da*	—	9.577	9.095	6.691	10.18	6.114	10.51	13.01	7.942	6.304	5.971
Db*	—	-10.67	-3.660	-4.224	-9.232	-13.18	-11.64	-7.923	-13.94	-4.142	-3.033
Dc*	—	-5.649	-0.897	-2.603	-4.305	-9.925	-5.362	-1.263	-8.681	-2.701	-1.871
k/s	0.610	5.140	8.990	12.23	14.09	18.59	3.330	4.760	4.510	11.82	8.624

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH



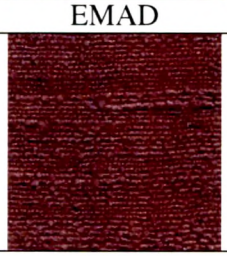
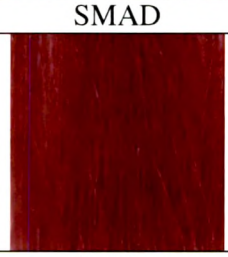
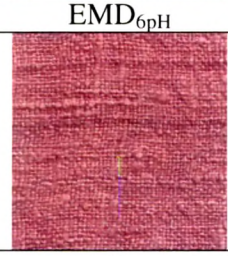
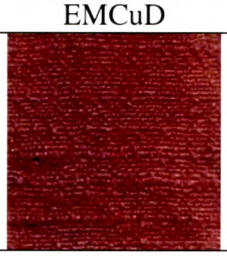
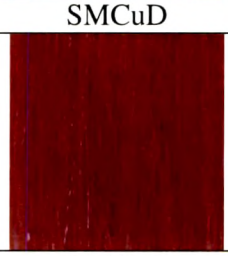
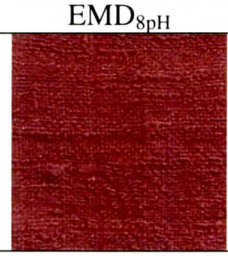
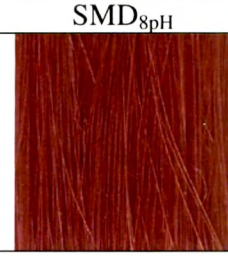
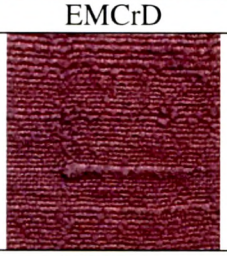
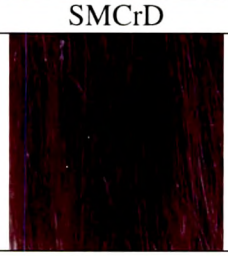
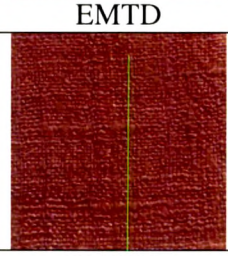
Graph 4.7b: Reflectance values of Madder and Ratanjot composite dye on Sisal fibre.

As observed from the table 4.7b the DL* reading indicate that all the samples were dark in appearance. The movement of the coordinates from the centre of the square towards the edges of the plane indicated that the samples were moving towards being more distinct in terms of hue and not having a grayish appearance. Visual assessment also indicates that the samples tended towards the red violet region of the colour wheel. The highest k/s values were of the samples pretreated with ferrous sulphate and potassium dichromate respectively.

4.1.8. Colour palette and reflectance spectrophotometric analysis of eri and sisal samples dyed with madder flame of forest dye

Madder and flame of forest were combined to create a palette towards the orange range of colours. It was observed that inspite of the equal proportions of the dyes mixed the contribution of the yellow dye (flame of forest flower) towards the

development of a shade was quite meager. Amongst the composite mixture madder dye was the dominant dye, resulting into a colour palette obtained with very light undertones of yellow.

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

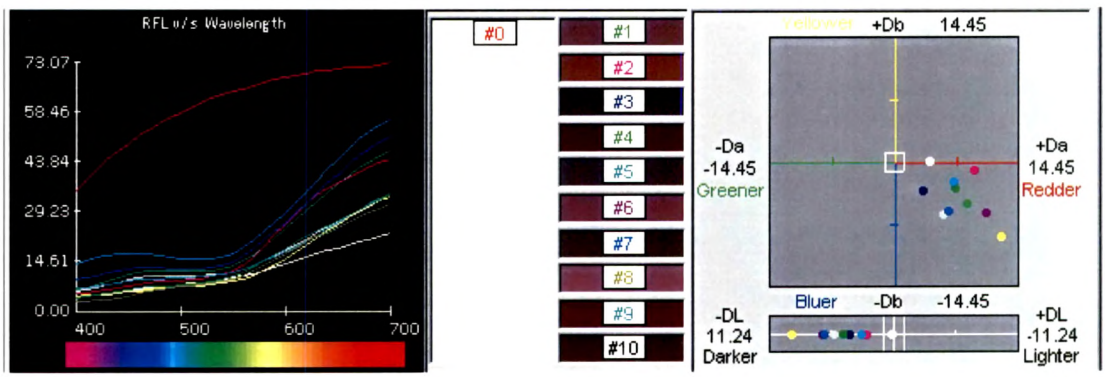
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.8: Colour palette of Madder and Flame of Forest composite dye on Eri silk and Sisal fibre for variables under study.

Table 4.8 a: Reflectance values of Madder and Flame of Forest composite dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	$EMD_{4\ pH}$	$EMD_{6\ pH}$	$EMD_{8\ pH}$	EMTD	EMPRD
DL*	—	-4.168	-2.472	-4.044	-4.638	-5.354	-6.398	-6.253	-9.244	-2.932	-0.125
Da*	—	8.495	9.220	3.305	7.014	5.665	10.74	6.343	12.54	6.843	4.058
Db*	—	-4.922	-0.804	-3.280	-3.146	-6.085	-5.863	-5.682	-8.591	-2.213	0.132
Dc*	—	-1.327	2.302	-2.672	-0.882	-4.058	-0.253	-3.323	-0.116	-0.190	0.804
k/s	0.410	5.420	7.620	9.540	9.320	6.110	3.780	5.710	2.250	9.520	15.27

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.8b: Reflectance values of Madder and Flame of Forest composite obtained on Eri Silk.

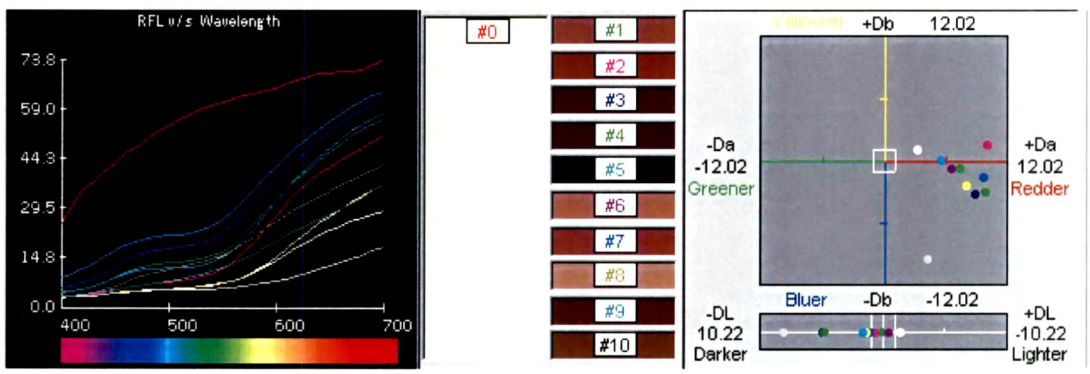
Plot of the Da*, Db* and Dc* values in Graph 4.8b indicated that the samples fall into the red blue region but mostly away from the blue axis. This indicated that madder dye is the main colour giving component in this mixture and the yellow brown tones of flame of forest are subdued by the red maroon madder. Study of the readings of DL* indicated that this mixture exhibited a change in colour at alkaline pH. It was also observed while dyeing that on addition of sodium carbonate to adjust pH of the dye liquor the colour brightens up and hence the DL* plot of the sample shows that it is exactly on the square plane with a slight shift towards positive red axis indicating that the colour is a red of the middle grey value hence it appears a grey-pink. The k/s values of the dye indicated good colour strength obtained; samples

pretreated with tea, copper sulphate, pomegranate rind pretreated sample and potassium dichromate.

Table 4.8 b: Reflectance values of Madder and Flame of Forest composite dye on Sisal fibre.

	Control	SD	SMAD	SMCuD	SMCrD	SMFeD	$SMD_{4\ pH}$	$SMD_{6\ pH}$	$SMD_{8\ pH}$	SMTD	SMPRD
DL*	—	-0.151	-0.656	-5.082	-4.932	-8.218	0.488	-1.152	-1.419	-1.738	1.432
Da*	—	7.323	10.18	8.877	9.840	4.304	6.610	9.745	7.958	5.565	3.211
Db*	—	-0.824	1.622	-3.237	-3.021	-9.525	-0.677	-1.588	-2.338	0.158	1.087
Dc*	—	0.733	4.107	-0.682	0.022	-8.418	0.595	1.177	-0.357	1.033	1.354
k/s	0.620	7.950	12.27	13.87	13.47	13.92	5.850	7.900	3.500	12.04	12.03

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

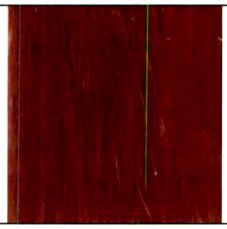
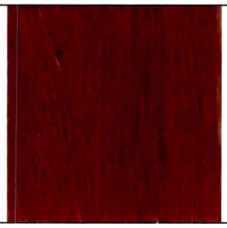
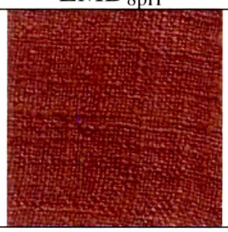
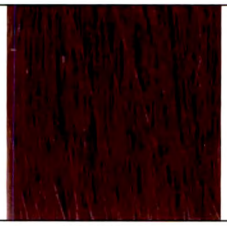


Graph 4.8b: Reflectance values of Madder and Flame of forest composite dye on Sisal fibre.

When the DL* plots of the Eri and Sisal samples dyed with the composite mixture of Madder and Flame of forest dye were compared it was observed that the Sisal fibre sample were luminous/brighter in comparison to the Eri silk samples. Most of the Sisal fibre samples were either on the central plane of the DL* axis or just one step above or below the plane. This indicated that the colour obtained was of the middle value. There was a marked movement of the colour coordinates towards the red axis which indicated that the colour obtained by this dye mixture had distinct hues. The highest k/s values were how ever observed with all metal mordants and also with natural mordants tea and pomegranate rind. Hence, it was concluded that in terms of the colour yield natural mordant could be substituted for metal mordants which gave similar colours.

4.1.9. Colour palette and reflectance spectrophotometric analysis of eri and sisal samples dyed with madder marigold dye

Separately extracted madder and marigold dye were combined in equal proportion to dye Eri silk and Sisal fibre fabric. The colours obtained had a deep hue, although no olive green influences were observed in the colours. A wide range of colours were obtained ranging from heart wood brown to light brown to coir brown and grayish red and beige.

Eri Silk	Sisal Fibre	Eri Silk	Sisal Fibre
			
ED	SD	EMD_{4pH}	SMD_{4pH}
			
EMAD	SMAD	EMD_{6pH}	SMD_{6pH}
			
EMCuD	SMCuD	EMD_{8pH}	SMD_{8pH}
			
EMCrD	SMCrD	EMTD	SMTD
			
EMFeD	SMFeD	EMPRD	SMPRD

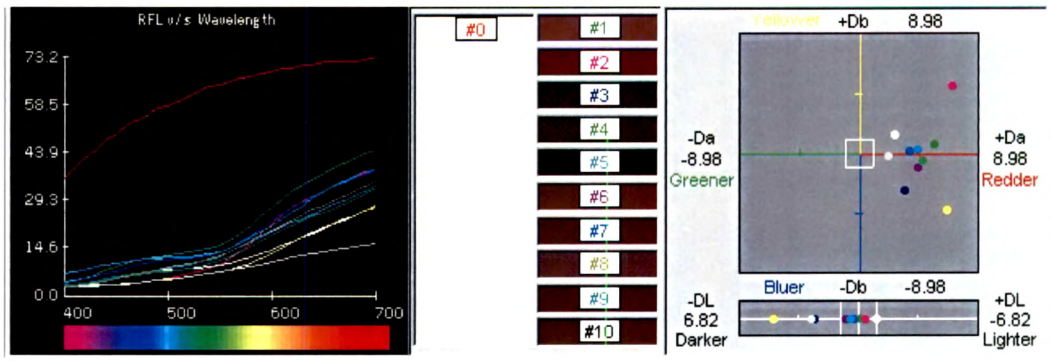
Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.

Plate 4.9: Colour palette of Madder and Marigold composite dye on Eri silk and Sisal fibre for variables under study

Table 4.9 a: Reflectance values of Madder Marigold dye on Eri silk fabric.

	Control	ED	EMAD	EMCuD	EMCrD	EMFeD	EMD_4 pH	EMD_6 pH	EMD_{8p} H	EMTD	EMPRD
DL*	—	0.068	0.376	-2.496	-2.715	-2.686	-0.789	-0.301	-4.818	-0.464	1.058
Da*	—	4.738	6.982	3.353	5.632	2.200	4.380	3.759	6.592	4.451	2.721
Db*	—	-0.579	5.167	-2.841	0.642	-0.158	-1.015	0.190	-4.329	0.248	1.387
Dc*	—	0.361	6.530	-2.237	1.826	0.075	-0.173	0.777	-2.070	1.041	1.689
k/s	0.400	7.960	16.55	11.67	15.19	16.54	8.750	11.58	5.270	12.88	13.62

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.9a: Reflectance values of Madder Marigold dye obtained on Eri silk.

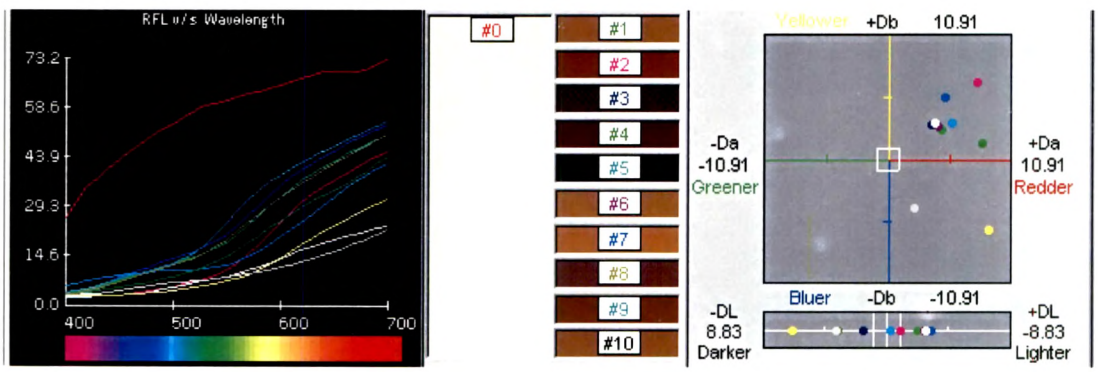
As it is observed from the table 4.9a, the DL* values showed that only samples ED, EMAD and EMPRD exhibited positive lightness; this means that these samples were light as compared to the rest of the samples. This was due to the fact that sample ED had no treatment on it except the dy. The dye anchoring was not strong when only myrobolan was present onto the fabric. Sample EMAD was pretreated with alum, here alum acts as a strong mordant but the colour yield was brighter and hence the positive DL* values. As in the case if sample 10 the pretreatment given to the sample is pomegranate rind extract. It was Gallo tannin and

did not have fastness equivalent to the tannin obtained form Myrobolan. Hence, it was deduced that the lightness/darkness of the samples depended upon the type of pretreatment given to the fabric. It was observed from the plot of samples that, all were scattered into the red yellow and red blue region; more so towards the red area. Hence, we may say that the colour of madder dominates in this mixed dye solution. This was also confirmed by visual inspection of the samples.

Table 4.9 b: Reflectance values of Madder Marigold dye on Sisal fibre.

	Control	SD	SMAD	SMCuD	SMCrD	SMFeD	$SMD_{4\,pH}$	$SMD_{6\,pH}$	SMD_{8pH}	SMTD	SMPRD
DL*	—	2.166	0.943	-1.664	-3.458	-3.653	2.662	3.205	-6.831	0.261	2.756
Da*	—	4.705	7.950	3.904	8.376	2.392	4.499	5.053	8.911	5.718	4.156
Db*	—	2.596	6.884	3.073	1.397	-4.277	2.969	5.490	-6.194	3.233	3.298
Dc*	—	3.197	8.224	3.485	3.274	-4.019	3.509	6.090	-2.932	4.072	3.752
k/s	0.610	10.12	16.39	18.39	17.06	14.80	9.180	9.010	6.010	11.72	10.97

Where: E = Eri, S = Sisal, M = pretreated with Myrobolan, A = mordanted with Alum, Cu = mordant with Coppersulphate, Cr = Mordanted with Potassium dichromate, Fe = mordanted with Ferrous sulphate, T = premordanted with Tea, PR = premordanted with pomegranate rind and D = Dyed at extract pH.



Graph 4.9b: Reflectance values of Madder Marigold dye on Sisal fibre.

A review of the plot of dyed samples from Graph 4.9b indicated that the resultant colours obtained on Sisal fibre dyed with madder marigold dye mixture; were mostly red yellow and red blue in nature. It was observed that more samples were dyed in the red yellowish shade compared to red blue. Two sample treatments however qualify a distinct mention: (i) Sample pretreated with alum and dyed with the madder marigold composite dye. (ii) Sample dyed with madder marigold dye mixture at 8pH.

The alum sample exhibits a distinct move towards the red orange pure hue. And the 8pH dyed sample shows a move towards violet more towards the red region. The k/s readings of the samples exhibit that five out of the ten dyes have a k/s score above 10 indicating a dark value of the colour obtained.

4.2 Results of the testing of Eco-parameters of the dyed samples.

With a pre-requisite to make value added natural dyed products truly eco friendly, it was necessary to quantify the amount of metal mordants present on the dyed fabrics. With this in view Atomic Absorption Spectra Studies were done for samples pretreated with metal mordants. The metal pretreated dyed samples were extracted in an acid perspiration solution.

As the sample to be evaluated for heavy metals was fabric acidic perspiration solution is prepared. The solution was prepared as follows:

- 0.5 gm of 1-histidine monohydrochloride monohydrate
- 5 gm of sodium chloride
- 2.2 gm of sodium dihydrogen orthophosphate dehydrate, are all added to 1 litre of water and brought to pH 5.5 with 1N acetic acid solution

A 5 gm sample of finely cut fabric is soaked in 100 ml of acidic perspiration solution, which is kept in a water bath for 60 minutes at 40°C. The solution is then filtered and taken for reading on Atomic Absorption Spectrophotometer (AAS). A blank (only acidic perspiration solution) was first taken for the control reading. And then the extracted filterate solutions were run on the AAS for reading. AAS is a single element method. One element is determined at a time and the instrumental parameters are optimized for the next element and the series is repeated.

The results indicated that readings of Copper was under permissible limits, but Chromium was above it hence the chromium concentration was reduced by optimizing the potassium dichromate concentration and further dyeing was carried out at 2.5% potassium dichromate which was the optimum concentration obtained as a result of the optimization process.

Table 4.10: Results of the Atomic Asbsorption Spectra Analysis of Eri Silk and Sisal Fibre

	Permissible limits for heavy metals	Residue on Eri Silk Fabric	Residue on Sisal Fibre
Residue on fabric at 5% Coppersulphate	< 50 ppm	39.71ppm	33.09 ppm
Residue on fabric at 5% potassium dichromate	< 2ppm	17.56ppm	13.49 ppm
Residue on fabric at 2.5% potassium dichromate	< 2ppm	2.9 ppm	2.1 ppm

4.3 Results of optical density readings of spent dye-bath.

The spent dye liquor left after dyeing procedure was assessed for optical density of the solution. It was ascertained in order to have a qualitative measure of the dye exhaustion from the dye bath. Hence, higher the transmittance obtained; better was the dye exhaustion from the dye liquor. Proportionately higher the transmittance of the dye liquor at a particular wavelength will also mean higher k/s values in most cases.

Table 4.11: Optical Density and Transmittance readings of Madder Dye after premordanting and dyeing at different pH.

	Madder			
λmaxima.	**640nm**			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.44**	**38**		
After dyeing @4pH	**0.07**	**86**	**18.42**	**10.42**
After dyeing @6pH	**0.35**	**45**	**126.31**	**4.94**
After dyeing @8pH	**0.31**	**48**	**26.3**	**3.58**
Tea premordanted	**0.31**	**48**	**26.3**	**9.81**
Pom.Rind λσpremordanted	**0.37**	**42**	**10.52**	**4.4**
Sisal Fibre				
@λmaxima.of extract	**0.5**	**32**		
After dyeing @4pH	**0.15**	**71**	**12.5**	**5.37**
After dyeing @6pH	**0.62**	**36**	**121.87**	**7.85**
After dyeing @8pH	**0.38**	**42**	**31.25**	**4.32**
Tea premordanted	**0.39**	**40**	**25**	**8.65**
Pom.Rindpremordanted	**0.42**	**38**	**18.75**	**7.11**

It was observed form the above data that dyeing at 4pH gave the highest absorbance value, the lightness value of the sample also confirmed that the sample was dark. Hence, it was concluded that madder dyes silk better at acidic pH. Lowest values were obtained in case of pomegranate rind pretreated fabric; this could be due to the fact that pomegranate rind tannin leached out of the fabric as it had poor fastness in aqueous solution.

Table 4.12: Optical Density and Transmittance readings of Marigold Dye after premordanting and dyeing at different pH.

	Marigold			
λmaxima.	**560 nm**			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.48**	**33**		
After dyeing @4pH	**0.09**	**80**	**45.45**	**11.11**
After dyeing @6pH	**0.32**	**48**	**142.42**	**14.26**
After dyeing @8pH	**0.28**	**52**	**57.57**	**11.53**
Tea premordanted	**0.36**	**44**	**33.33**	**12.58**
Pom.Rindpremordanted	**0.65**	**24**	**-27.27**	**8.52**
Sisal Fibre				
@λmaxima.of extract	**0.6**	**25**		
After dyeing @4pH	**0.28**	**52**	**52**	**11.54**
After dyeing @6pH	**0.42**	**38**	**108**	**11.69**
After dyeing @8pH	**0.7**	**20**	**-20**	**12.27**
Tea premordanted	**0.54**	**28**	**12**	**11.42**
Pom.Rindpremordanted	**0.52**	**30**	**20**	**11.23**

There was a marked difference in the percent dye absorption of marigold dye at 4 and 8 pH. Table 4.12 shows an approximate difference of 90 in case if percent dye absorption at acidic and alkaline pH. This was attributed to the fact that acidic fermentation of marigold leaves is neutralized by dyeing in alkaline medium. Hence the dye absorption was less in case of dyeing at alkaline medium.

Table 4.13: Optical Density and Transmittance readings of Henna Dye after premordanting and dyeing at different pH.

	Henna			
λmaxima.	**660 nm**			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.30**	**50**		
After dyeing @4pH	**0.15**	**70**	**18**	**9.13**
After dyeing @6pH	**0.23**	**59**	**40**	**11.26**
After dyeing @8pH	**0.29**	**51**	**2**	**12.72**
Tea premordanted	**0.24**	**58**	**16**	**9.31**
Pom.Rindpremordanted	**0.35**	**45**	**-10**	**5.58**
Sisal Fibre				
@λmaxima.of extract	**0.42**	**39**		
After dyeing @4pH	**0.38**	**42**	**7.69**	**3.52**
After dyeing @6pH	**0.33**	**42**	**7.69**	**4.56**
After dyeing @8pH	**0.43**	**37**	**-5.12**	**2.65**
Tea premordanted	**0.38**	**42**	**7.69**	**6.4**
Pom.Rindpremordanted	**0.40**	**40**	**2.56**	**4.712**

Henna is a dye of the quinonoid group with the main colouring component as lawsone. This dye behaved like an acid dye in most cases when dyeing protein fibre. The fibres taken for this experiment were proteinic and cellulosic and hence it was observed that the percent dye absorption readings of this dye were very low in case of cellulosic fibre. Another notable point in the table was that it showed very minimal to negative dye absorption when dyed at alkaline pH; which could be a result of a neutralization reaction between the medium and the dye molecule.

Table 4.14: Optical Density and Transmittance readings of Flame of forest Dye after premordanting and dyeing at different pH.

	Flame of forest			
λmaxima.	600 nm			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.59**	**26**		
After dyeing @4pH	**0.21**	**62**	**138.46**	**8.8**
After dyeing @6pH	**0.35**	**58**	**123.07**	**8.45**
After dyeing @8pH	**0.57**	**28**	**7.69**	**7.03**
Tea premordanted	**0.14**	**71**	**52.54**	**7.72**
Pom.Rindpremordanted	**0.36**	**44**	**69.23**	**8.51**
Sisal Fibre				
@λmaxima.of extract	**0.27**	**54**		
After dyeing @4pH	**0.21**	**61**	**12.96**	**6.810**
After dyeing @6pH	**0.15**	**70**	**29.62**	**7.020**
After dyeing @8pH	**0.4**	**40**	**-25.92**	**5.080**
Tea premordanted	**0.25**	**58**	**7.40**	**7.050**
Pom.Rindpremordanted	**0.25**	**56**	**3.70**	**8.521**

It was observed by (.....) that the dye extraction was good at lower temperatures when flame of forest was extracted in acidic medium; and it is also observed according to this table that dye exhaustion is good at 4pH; confirming that the dye obtained from flame of forest petals was of acidic type. It did not have natural affinity towards cellulosic fibre but it dyed proteins well. This was confirmed by the percent dye absorption readings in the above table in case of eri silk fabric and sisal fabric. The above readings also showed that dyeing at alkaline pH had given very poor results and the exhaustion is only 7.69 percent and -25.92 percent in case of eri

silk fabric and sisal fibre; the reasons for such low readings could be the reaction of the dye molecules with sodium carbonate where the colour of the dye solution brightens up; this colour is only superficial in case of fabric dyeing as the bright yellow orange colour bled off during the soaping procedure after dyeing.

Table 4.15: Optical Density and Transmittance readings of the Ratanjot Dye after premordanting and dyeing at different pH.

	Ratanjot			
λmaxima.	**700 nm**			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.18**	**65**		
After dyeing @4pH	**0.18**	**65**	**1.53**	**1.82**
After dyeing @6pH	**0.12**	**74**	**13.84**	**5.31**
After dyeing @8pH	**0.22**	**60**	**-7.69**	**5.25**
Tea premordanted	**0.14**	**72**	**10.76**	**8.77**
Pom.Rindpremordanted	**0.18**	**66**	**1.53**	**1.49**
Sisal Fibre				
@λmaxima.of extract	**0.18**	**65**		
After dyeing @4pH	**0.19**	**64**	**-1.53**	**3.24**
After dyeing @6pH	**0.17**	**67**	**3.07**	**4.01**
After dyeing @8pH	**0.24**	**58**	**-10.76**	**4.00**
Tea premordanted	**0.165**	**68**	**4.61**	**7.61**
Pom.Rindpremordanted	**0.17**	**67**	**3.07**	**4.736**

The yield of Ratanjot dye was an ash grey solution on aqueous extraction and the colouring component in solvent medium is more towards red orange. The dye did

not have good exhaustion properties at alkaline or acidic pH, but dyed well with the aid of metal mordants. However, it is noteworthy that it gave 10.76 percent dye exhaustion with tea pretreated fabric and 13.84% at 6pH (pH of the extract). Hence, it was concluded that extract pH with metal mordant pretreated fabric would gave better dye exhaustion on to the fabric.

Table 4.16: Optical Density and Transmittance readings of the Acacia catechu Dye after premordanting and dyeing at different pH.

	Acacia catechu			
λmaxima.	700 nm			
Eri Silk	OD	T	% Dye absorption	k/s values
@λmaxima.of extract	0.24	58		
After dyeing @4pH	0.26	55	-5.17	1.63
After dyeing @6pH	0.40	40	-31.03	1.97
After dyeing @8pH	0.24	57	-1.72	5.34
Tea premordanted	-0.29	51	-12.06	3.87
Pom.Rindpremordanted	-0.65	22	-62.06	2.54
Sisal Fibre				
@λmaxima.of extract	0.24	58		
After dyeing @4pH	0.26	54	-6.89	2.05
After dyeing @6pH	0.47	34	-37.03	2.64
After dyeing @8pH	0.56	27	-53.44	4.89
Tea premordanted	0.18	65	12.06	5.12
Pom.Rindpremordanted	0.20	63	8.62	5.09

Acacia catechu had substantivity towards cellulosic fibre which was observed in the form of higher dye absorption value by sisal fibre compared to Eri silk fabric.

The dye exhibited better exhaustion with tea pretreated fabric and good exhaustion at alkaline pH. Similar observation was also made in case of the k/s values of the dyed samples. Highest k/s was found in case of dyeing at 8pH for Eri silk fabric and for sisal the highest k/s was observed for fabric pretreated with tea and then dyed. Negative values for percent dye absorption was due to the fact that catechu dye had very fine suspended particles and some of the particles that only had mechanical deposition on the surface of the fabric was loosened out during the exhaust dyeing procedure.

Table 4.17: Optical Density and Transmittance readings of the Dyes after premordanting and dyeing at different pH.

	Madder Marigold			
Amaxima.	600nm			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.48**	**33**		
After dyeing @4pH	**0.09**	**80**	**142.42**	**8.75**
After dyeing @6pH	**0.32**	**48**	**45.45**	**11.58**
After dyeing @8pH	**0.28**	**52**	**57.57**	**5.27**
Tea premordanted	**0.36**	**44**	**33.33**	**12.88**
Pom.Rindpremordanted	**0.65**	**24**	**-27.27**	**13.68**
Sisal Fibre				
@λmaxima.of extract	**0.6**	**25**		
After dyeing @4pH	**0.28**	**52**	**108**	**9.18**
After dyeing @6pH	**0.42**	**38**	**52**	**9.01**
After dyeing @8pH	**0.7**	**20**	**-20**	**6.01**
Tea premordanted	**0.54**	**28**	**12**	**11.72**
Pom.Rindpremordanted	**0.52**	**30**	**20**	**10.97**

The percent dye absorption was calculated by means of the difference in transmittance readings that were taken before and after dyeing. It is observed that the madder marigold dyeing gives very good exhaustion at the extract pH; and the k/s values also gave a reading of 9.01 and 11.58 for sisal fibre and silk fabric respectively. It was observed that the k/s values were higher for tea and pomegranate rind pretreated fabrics; the reason for this could be that tea and pomegranate rind themselves impart a good tan brown colour to the fabric during pretreatment. Hence, the k/s values of the samples treated with these two natural mordants will definitely remain higher due to double colour application.

Table 4.18: Optical Density and Transmittance readings of the Dyes after premordanting and dyeing at different pH.

	Madder Flame of forest			
Λmaxima.	**650nm**			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.52**	**33**		
After dyeing @4pH	**0.45**	**36**	**9.09**	**3.78**
After dyeing @6pH	**0.39**	**40**	**21.21**	**5.71**
After dyeing @8pH	**0.44**	**38**	**15.15**	**2.25**
Tea premordanted	**0.23**	**60**	**81.81**	**9.52**
Pom.Rindpremordanted	**0.37**	**42**	**27.27**	**15.27**
Sisal Fibre				
@λmaxima.of extract	**0.38**	**43**		
After dyeing @4pH	**0.18**	**65**	**51.16**	**5.85**
After dyeing @6pH	**0.39**	**40**	**-6.9**	**7.9**
After dyeing @8pH	**0.39**	**40**	**-6.9**	**3.5**
Tea premordanted	**0.32**	**49**	**13.95**	**12.04**
Pom.Rindpremordanted	**0.34**	**47**	**9.3**	**12.03**

81.81 was the percent dye absorption value obtained in case of fabric pretreated with tea as a mordant and the corresponding k/s value is 9.52 at the same time the k/s for fabric pretreated with pomegranate rind is 15.27 and its percent dye absorption is 27.27; one may hence infer that with this particular mordant and dye combination the colour yield is darker with the pomegranate rind pretreated fabric compared to the tea premordanted Eri silk. Where as in the case of sisal fibre the k/s values of tea premordanted and pomegranate rind premordanted fabric was almost similar, leading to conclude that there was no difference in the darkness of the colour yield in the case of cellulosic fibre. The k/s values in case of fabrics premordanted with metal mordants were lower compared to those with natural mordants, hence one may substitute metal mordants for natural mordants while dyeing with this particular dye, mordant and fibre combination.

Table 4.19: Optical Density and Transmittance readings of the Dyes after premordanting and dyeing at different pH.

	Madder Ratanjot			
λmaxima.	690nm			
Eri Silk	**OD**	**T**	**% Dye absorption**	**k/s values**
@λmaxima.of extract	**0.31**	**48**		
After dyeing @4pH	**0.44**	**38**	**20.83**	**3.25**
After dyeing @6pH	**0.24**	**58**	**20.83**	**8.33**
After dyeing @8pH	**0.27**	**50**	**4.16**	**3.28**
Tea premordanted	**0.23**	**60**	**25.0**	**9.14**
Pom.Rindpremordanted	**0.28**	**54**	**33.33**	**14.69**
Sisal Fibre				
@λmaxima.of extract	**0.34**	**48**		
After dyeing @4pH	**0.37**	**67**	**39.58**	**3.33**
After dyeing @6pH	**0.39**	**51**	**7.5**	**4.76**
After dyeing @8pH	**0.31**	**49**	**2.08**	**4.51**
Tea premordanted	**0.28**	**54**	**8.33**	**11.82**
Pom.Rindpremordanted	**0.29**	**53**	**6.25**	**8.62**

From the above table it was observed that the percent dye absorption was the highest for Eri silk fabric premordanted with pomegranate rind at 33.33 percent and corresponding to it the k/s value is also the highest at 14.69, which indicated that the sample's colour value corresponded to the percentage of dye absorbed. The second dark sample with k/s value 9.14 and corresponding 25.0 percent dye absorption. In case of sisal fibre the highest k/s value stood at 11.82 in case of sample premordanted with tea indicating that in most of the cases the samples premordanted with natural mordant gave a darker hue compared to the metal mordants.

4.4 Results of the Fastness test of the dyed samples.

Wash fastness, Crock fastness and Light fastness were the three key agencies that faded colour for a textile of home use. Hence, the fastness of the dye to these agencies of fading was assessed according to the standard testing procedures discussed in the methodology chapter. The results of the test are discussed here.

Table 4.20: Fastness rating of Eri silk fabric and Sisal Fibres Dyed with Madder

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	4R	4	3	3	5	4D
EMAD	5	4	3	2	5	4-5D
EMCuD	5	4	3	2	5	4-5D
EMCrD	5	4	4	3	5	4-5D
EMFeD	5	4	3	3	5	4-5D
EMD_{4pH}	3	4	4	4	3	1-2
EMD_{6pH}	3-4	4	4	4	3	1-2
EMD_{8pH}	4	4	4	4	3	1-2
EMTD	4-5	4	4-5	4	5	5
EMPRD	4-5	4	4-5	4	5	5
Sisal						
SD	3-4	4	4-5	4-5	5	5
SMAD	4	4	3-4	4-5	5	5
SMCuD	4	4	4-5	4	5	4D
SMCrD	4	3-4	4	3-4	5	4D
SMFeD	4-5	4	4	3-4	5	4D

SMD_{4pH}	4	4	3-4	3	2-3	2
SMD_{6pH}	4	4	3-4	3-4	2	1-2
SMD_{8pH}	4-5	4	4	3-4	2	1-2
SMTD	4-5	4	4	4	5	5
SMPRD	4-5	4	4	4	5	5

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_{p}$M = pretreated with Myrobolan, $_{m}$A = mordanted with Alum, $_{m}$Cu = mordant with Coppersulphate, $_{m}$Cr = Mordanted with Potassium dichromate, $_{m}$Fe = mordanted with Ferrous sulphate, $_{m}$T = premordanted with Tea, $_{m}$PR = premordanted with pomegranate rind and D = Dye

It was observed from the table that Eri silk fabric had good to excellent wash fastness. As observed from the table the change in colour ratings for Eri silk ranged between 4-5 and 5 whereas the staining on white ratings were 4. This could be due to the fact that Eri silk fabric being a hand spun woven silk has a textured surface. Apart from penetration into the fibre there must be some superficial lodging of the dye that is removed during rigorous laundering procedure and hence the staining on white was observed. The rub fastness of the fabric ranged form average to poor, this was attributed to the fact that textured surface and superficial dye anchoring due to Van-der-Waals forces was removed during crocking test. Eri silk fabric dyed with madder showed excellent light fastness with metallic mordants, but poor light fastness was observed when samples with 4, 6, and 8pH were observed. It was also worth noting that the light fastness in cases of samples dyed with natural mordants Tea and Pomegranate rind was excellent for both ten and 20 hours of light exposure.

Wash fastness of Sisal fibre dyed with madder dye ranged between 4-5 and 3-4. The fastness ratings indicated that Sisal fibre dyed with madder dye had moderate to good wash fastness. Similar observation was made while studying its rub-fastness properties. The crock-fastness of Sisal fibre swatches dyed wit madder dye ranged from 3 in some cases to 3-4 and 4 in most of the cases hence it was averred that it had a poor rub fastness. The fastness to light ratings were in absolute contrast with the other two fastness readings for this particular dye and fibre combination as it was observed that sisal dyed with madder had excellent light fastness rating of 5 with all metallic mordants and pomegranate rind mordant for the first 10 hours of exposure to light. Effect of light started after the first observation of 10 hours when either fading or darkening of the samples was observed in the next 10 hours of exposure. It was noted that the samples pretreated with metallic mordants copper sulphate, potassium

dichromate and ferrous sulphate started becoming darker on prolonged exposure to light, where as samples treated at 4, 6 and 8pH had undergone fading and their readings were 2, 1-2 and 1-2 respectively.

Table 4.21: Fastness rating of Eri silk fabric and Sisal Fibres Dyed with Marigold Dye

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	4	4	3	3	4	3
EMAD	4	4	1	1	4	2
EMCuD	3	4	1	1	4	2
EMCrD	3	4	4	2	4	3
EMFeD	4	4	3	3	4	4D
EMD_{4pH}	3	4	3	4	3-4	3
EMD_{6pH}	3	4	3	4	3-4	3
EMD_{8pH}	3	4	3	4	4	3
EMTD	4	4	3-4	4	4	4
EMPRD	4	4	3-4	4	4	3
Sisal						
SD	4-5	4	4	4	3-4	3
SMAD	5	4	4	4	4	3-4
SMCuD	5	4	3-4	4	4	3-4
SMCrD	5	4	4	4	4	3-4
SMFeD	5	4	5	4	4	3-4
SMD_{4pH}	4-5	4	3-4	4-5	3-4	3
SMD_{6pH}	3-4	4	3-4	4	3-4	3
SMD_{8pH}	4	4	4	4-5	3-4	3
SMTD	4	4	4	4	4	4
SMPRD	4	4	4	4	4	4

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = Dye

Readings from the above table revealed that Eri silk fabric dyed with Marigold dye had and over all average to good performance to the agencies of wear like fastness to laundering, fastness to crocking and fastness on exposure to light. The wash fastness ratings ranged from average to good in terms of change in colour and staining on white reading was 4 for all the mordant-dye combinations; indicating good fastness to washing. It was peculiar to note that Eri silk dyed with marigold dye, premordanted with alum and copper sulphate obtained a reading of 1 indicating poor rub-fastness in both the cases. The overall light fastness rating also ranged from 3 to 4 indicating that the samples had an average to good fastness to light even on 20 hours of exposure to light. There were however a few exceptions like alum and copper sulphate premordanted samples which showed poor light fastness and ferrous sulphate premordanted samples which showed darkening on exposure to light.

It was noted from the above table that Sisal fibre dyed with marigold dye had excellent to good wash fastness. And interesting observation here was that the staining on white ratings for both Eri silk and Sisal fibre received a score of 4 in all the cases; this was due to the behavior of the dye as vat dye; as the colour was obtained not during exhaust dyeing but after the dyeing when the dyed samples are exposed to air during dyeing. The soaping off removes all the superficial dye and hence no dye leached out during dyeing. The above table also indicated that the rub-fastness and light-fastness ranged from average to good, with the readings than ranged from 3-4 and 4 in most of the cases.

Table 4.22: Fastness rating of Eri silk fabric and Sisal Fibres Dyed with Henna Dye

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	4	4	4	4	5	4R
EMAD	4	4	4	4	5	4R
EMCuD	4	4	4	4	5B	4
EMCrD	4	4	4	4	5B	4
EMFeD	4	4	4	4	5	5
EMD_{4pH}	3	4	3-4	3-4	5	4
EMD_{6pH}	3	4	3-4	3-4	4	4

EMD_{8pH}	4	4	3-4	3-4	4	4
EMTD	4-5	5	4	4	5	5
EMPRD	4-5	5	3-4	4	5	5
Sisal						
SD	4	4-5	4-5	4	5	4
SMAD	4-5	4	4-5	4	5	4
SMCuD	4	4-5	4-5	4	5	4
SMCrD	3-4	4	4-5	4	5	4
SMFeD	4-5	4-5	4-5	4	5	4
SMD_{4pH}	4	4-5	4	4	5B	4B
SMD_{6pH}	4-5	4	4-5	4	5B	4B
SMD_{8pH}	4	4	4-5	4-5	5	4
SMTD	4	4	4-5	3	5	4
SMPRD	4-5	4	3	3	5	4

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = D

"Protein substrate, tannin and an acidic dye make a good combination"; this was supported by the readings as observed from the table( ) . It was noted that Eri silk fabric pretreated with natural mordants tea and pomegranate rind (both being rich in tannin) gave excellent light fastness, excellent to good fastness to laundering and good to average rub-fastness. The readings for wash fastness for other pretreatments also ranged between 3 and 4 indicating average to good fastness. Crock fastness readings ranged between 4 and 3-4, which indicated that the Eri silk samples showed average to good rub-fastness. The samples pretreated with myrobolan and alum turned redder on 20 hour exposure to light; samples pretreated with copper sulphate and potassium dichromate showed bluish change in colour on exposure to light for duration of 10 hours. Rest of the samples showed good to excellent light fastness with the rating ranging from 4 and 5 points.

Sisal samples dyed with Henna dye had an over all below excellent performance. It is observed across all the tables that the overall reading assigned in each category ranged from 4-5 indicating that the performance of the dye and substrate to all the agencies of fading was between good and excellent. It was also worth noting that the dye showed excellent fastness to light when exposed to light for

10 hours and obtained a reading of four on 20 hour exposure to light which indicated that there was a slight fading seen on prolonged exposure with an exception of samples dyed at 4pH and 6pH turning bluer.

Table 4.23: Fastness rating of Eri Silk Fabric and Sisal Fibre Dyed with Flame of forest

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	3R	4	3	3	4	4
EMAD	4R	4	3	3	4	4
EMCuD	4R	4	3	3	5	4
EMCrD	4R	4-5	3	3	5	4
EMFeD	4R	4-5	2	3	5	4
EMD_{4pH}	3R	3	2	2	4	4
EMD_{6pH}	3R	3	2	2	4	4
EMD_{8pH}	4R	3	3	2-3	5	4
EMTD	4R	4-5	4	3-4	5	4-5
EMPRD	4R	4	4	3-4	5	4-5
Sisal						
SD	2-3	4-5	3-4	4	3	2
SMAD	2-3	4	4	4	3	3
SMCuD	2-3	4	3-4	4	3	2
SMCrD	2-3	3-4	2-3	4-5	3	3
SMFeD	2-3	4	4	4	3-4	3-4
SMD_{4pH}	4	3-4	4	4-5	4	4
SMD_{6pH}	4	4	4	4	4	4
SMD_{8pH}	4	4	4	4	4	4
SMTD	4	4	4	4	4	4
SMPRD	4	4-5	3-4	3-4	4	3

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = Dye

Yellow dyes are notoriously known for their fugitive nature particularly the yellow derived from turmeric. Flame of forest was natural dye yielding yellow colour. The observation made according to the table indicated that the dyes falling in the yellow colour genre had similarity in fading characteristics. As observed from the tables the dye showed fair to poor rub fastness in case of Eri silk and Sisal fibre samples dyed with each of the mordant combinations. The wash fastness characteristic of Flame of forest dye was good in case of Eri silk fabric but showed average to poor fastness in case of Sisal fibre. Light fastness of Eri silk dyed withFlame of forest dye was excellent in case of 10 hours exposure to light and gradually started fading upon 20 hours exposure to light. The rate and extent of change in colour (ΔE) on exposure was different for different mordants. The high resistance of the dye to light fading indicates that the dye is present in a highly aggregated form in silk. Whereas, light fastness of Sisal fibre dyed with Flame of forest dye was average to good with the sample ratings ranging from 3 to 4.

Table 4.24: Fastness rating of Eri Silk fabric and Sisal Fibre Dyed with Ratanjot

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	4	4-5	3	3	5	3
EMAD	4	4-5	3	4	5D	3B
EMCuD	4	5	2	1	5	5
EMCrD	4	5	3	3	5	4
EMFeD	4	5	3	4	5B	3
EMD_{4pH}	4	4-5	3	3	4-5B	4
EMD_{6pH}	4	4-5	3	3	4-5B	4
EMD_{8pH}	5	4-5	3	3	5	4
EMTD	4	4-5	3	3-4	5	4
EMPRD	4	4-5	3	3-4	5	4
Sisal						
SD	4	5	3-4	4	3-4	3
SMAD	4-5	5	3	4-5	3-4	3
SMCuD	4-5	5	3-4	4-5	5	4

SMCrD	4-5	5	3	4	5	4
SMFeD	4	5	3-4	3-4	5	4
SMD_{4pH}	4	5	3	3	4-5	3
SMD_{6pH}	4-5	5	3	3-4	4	3
SMD_{8pH}	4-5	5	3	3-4	4	3-4
SMTD	4-5	5	3-4	4	4	3-4
SMPRD	4-5	5	3-4	4	4	3-4

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = Dye

The extract of the dye appeared to be of two colours: a water soluble component which was violet grey in colour and a stick component that stained the walls of the dyeing vessel which appeared red in colour. The samples dyed with Ratanjot dye were slate grey in colour with a few exceptions where the reddish tinge dominated and the samples nearing a bluish grey where there was a variation in the natural pH of the dye. It was observed that the wash fastness for Eri and Sisal fibres dyed with Ratanjot dye was between excellent and good; indicative of the fact that the exhaust dyeing has helped the dye to penetrate deep into the pores of the fibre structure resulting into a good wash fastness. It was observed that though the wash fastness of the dye was very good, it did not show good fastness to crocking. This was attributed to the idea that some dye molecules that were not completely exhausted into the fibre structure would dislodge resulting into poor rub fastness of the dye. Ratanjot dye obtained average to good fastness to light. Hence it could be concluded that the dye molecules that absorbed a particular wavelength of dye also had a mechanism to use the energy obtained from that wavelength. It was observed in some cases that the samples became darker and bluer; this is ascribed to the dye forming new bonds with the existing chemicals and hence resulting into a bluer or darker change from the original colour of dye.

Table 4.25: Fastness rating of Eri Silk fabric and Sisal Fibre Dyed with Acacia catechu

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10 hrs	Rating at 20hrs
Eri Silk						
ED	4	4-5	4	4	5	5
EMAD	4	4-5	4	4	5	3B
EMCuD	4	4-5	3	3	5	4
EMCrD	4	4-5	4	4	5	5
EMFeD	4	4-5	3	3	5	5
EMD_{4pH}	4-5	4-5	3	3	4-5	4-5D
EMD_{6pH}	4-5	4-5	3	3	4-5	4-5D
EMD_{8pH}	4	4-5	4-5	4	4-5	4D
EMTD	4	4-5	4-5	4-5	5	5
EMPRD	4	4-5	4-5	4	5	5
Sisal						
SD	4	4	4	3-4	5	5
SMAD	4	5	4	4	5	5
SMCuD	4	5	3	3	5	5
SMCrD	4	5	4	3-4	5	5
SMFeD	4	5	3	3	5	5
SMD_{4pH}	4	4	4	3	5	4-5
SMD_{6pH}	4	4	4	3	4	4
SMD_{8pH}	4	4	4	3	4	4
SMTD	4	4-5	4	3	5	4-5
SMPRD	4	4-5	4	3	5	4-5

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = Dye

The staining on white properties of Eri silk samples were found to be in the range of 4 to 5 and for change in colour the rating recorded was 4 except in the case of samples dyed at 4 and 6pH. Similar observation was observed in case of Sisal fibre also where there was a difference of one reading between changes in colour and staining of white. This means that the dye marginally bled during the wash fastness testing but it does not stain the adjacent white fabric. During dyeing it is observed that the catechu dye is relatively dormant in the initial phases of dyeing but pick up

colour exponentially on addition of auxiliaries. Hence, it could be concluded that even though the colour may bleed the dye from catechu posed no harm in terms of staining of adjacent material. The dye shows average to good fastness to crocking in both the cases i.e. dry and wet rub fastness for Eri and Sisal fibre samples. It was also observed that the light fastness of Eri and Sisal fibre samples ranked between excellent and good. It was observed that the samples treated with metallic mordants had excellent light fastness whereas samples pretreated with natural mordants ranked slight lower with a reading ranging between 4-5.

Table 4.26: Fastness rating of Eri Silk fabric and Sisal Fibre Dyed with combination of Madder and Marigold

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	5	4	3	3	4	3
EMAD	5	4-5	2	2	4	2
EMCuD	4	4	2	2	4	2
EMCrD	4	4	4	2	4	3
EMFeD	5	4	3	3	4	4D
EMD_{4pH}	4	4	3	4	3-4	3
EMD_{6pH}	4	4	3	4	3-4	3
EMD_{8pH}	4	4	3	4	4	3
EMTD	5	4-5	3-4	4	4	4
EMPRD	5	4-5	3-4	4	4	3
Sisal						
SD	4-5	4	4	4	3-4	3
SMAD	5	4-5	4	4	4	3-4
SMCuD	5	4-5	3-4	4-5	4	3-4
SMCrD	5	4-5	4	4	4	3-4
SMFeD	5	4-5	5	4-5	4	3-4
SMD_{4pH}	4-5	4	3-4	3-4	4-5	3-4
SMD_{6pH}	3-4	4	3-4	3-4	4-5	3-4
SMD_{8pH}	4	4	4	4-5	4-5	3-4
SMTD	4	4-5	4	4	4	4
SMPRD	4	4-5	4	4	4	4

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = Dye

It was observed from the table that the wash fastness rating of Eri silk fabric dyed with a composite mixture ranged between 5 and 4-5. Hence, it could be averred that the wash fastness of the dye with Eri silk fabric was good to excellent. But the rub-fastness of the dye on Eri silk was only fair to good, as observed from the table the readings ranged from 2 to 4. The dry and wet rub fastness of samples pretreated with Alum and Copper sulphate were fair. Similarly both the samples yielded good to poor light fastness on 10 and 20 hours of exposure respectively.

Fastness to laundering, crocking and exposure to light was comparatively better for madder marigold dye on Sisal fibre substrate. Light fastness of madder marigold dye was between 3-4 and 4-5. Similar readings were obtained for dry and wet rub-fastness. Wash fastness rating of madder marigold dye was marginally better with average fastness ratings of 4-5 and 5, indicating that the fastness ranged from good to excellent.

Table 4.27: Fastness rating of Eri Silk fabric and Sisal Fibre Dyed with combination of Madder and Flame of forest

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	4R	4	3	3	4	4
EMAD	4R	4	3	3	4	4
EMCuD	5	4	4	3	5	4
EMCrD	5	4-5	4	3	5	4
EMFeD	5	4-5	3	3	5	3F
EMD_{4pH}	5	4	4	4	4	3F
EMD_{6pH}	3R	3	2	2	4	3F
EMD_{8pH}	4R	3	3	2-3	5	4
EMTD	4R	4-5	4	3-4	5	4-5
EMPRD	4R	4	4	3-4	5	4-5
Sisal						
SD	2-3	4-5	3-4	4	3	2
SMAD	2-3	4	4	4	3	3
SMCuD	2-3	4	3-4	4	3	2
SMCrD	4	3-4	2-3	4-5	3	3
SMFeD	3	4	4	4	3-4	3-4
SMD_{4pH}	2-3	3-4	4	4-5	4	4

SMD_{6pH}	4	4	4	4	4	4
SMD_{8pH}	3-4	4	4	4	3-4	4
SMTD	4	4	4	4	4	4
SMPRD	4	4-5	3-4	3-4	4	3

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_{p}$M = pretreated with Myrobolan, $_{m}$A = mordanted with Alum, $_{m}$Cu = mordant with Coppersulphate, $_{m}$Cr = Mordanted with Potassium dichromate, $_{m}$Fe = mordanted with Ferrous sulphate, $_{m}$T = premordanted with Tea, $_{m}$PR = premordanted with pomegranate rind and D = Dye

It was worth noted from the table 4.27 that while flame of forest dye was mostly subdued by madder (results from the k/s studies of the dye mixture), yet it shows a peculiar yellow dye behavior during wash fastness testing. As noticed from the above table most of the Eri silk samples showed a change in colour towards the red. This was also observed in Eri samples dyed with pure Flame of Forest dye. The readings indicate that Eri silk has better wash fastness compared to Sisal fibre samples dyed with the composite dye mixture of madder and flame of forest dye. It was also observed that the light fastness of the dye is poor on a cellulose substrate whereas the protein substrate has better light fastness. The state of aggregation of the dyes has an appreciable influence on the fastness to light. Usually the greater the average sizes of the particles, the higher the fastness to light [C. H. GILES, et. al., Textile ResearchJ. 30 (I96o), 934.]. It was observed here that silk fibre being amphoteric compared to sisal fibre allows for better aggregation of the dye and hence good light fastness.

Table 4.28: Fastness rating of Eri Silk fabric and Sisal Fibre Dyed with combination of Madder and Ratanjot

Sample	Wash fastness		Rub fastness		Light fastness	
	Change in colour	Staining on white	Staining on white Dry	Staining on white Wet	Rating at 10hrs	Rating at 20hrs
Eri Silk						
ED	5	4-5	3	3	5F	3F
EMAD	4-5	4-5	3-4	4	5D	3D
EMCuD	4-5	5	2-3	1-2	5	5
EMCrD	4	5	3-4	3	5	4
EMFeD	4	5	3-4	4	5D	3
EMD_{4pH}	4-5	4-5	3-4	3-4	4-5D	4
EMD_{6pH}	4-5	4-5	3	3	4-5D	4F

EMD_{8pH}	5	4-5	3	3	5	4F
EMTD	4	4-5	3-4	3-4	5	4
EMPRD	4	4-5	3-4	3-4	5	4
Sisal						
SD	4	5	3-4	4	3-4	3
SMAD	4-5	5	3	4-5	3-4	3
SMCuD	4-5	5	3-4	4-5	5	4
SMCrD	4-5	5	3	4	5	4
SMFeD	4	5	3-4	3-4	5	4
SMD_{4pH}	4	5	3	3	4-5	3
SMD_{6pH}	4-5	5	3	3-4	4	3
SMD_{8pH}	4-5	5	3	3-4	4	3-4
SMTD	4-5	5	3-4	4	4	3-4
SMPRD	4-5	5	3-4	4	4	3-4

Where: R=Redder, B=Bluer, D=Darker, F=Fading, E = Eri, S = Sisal, $_pM$ = pretreated with Myrobolan, $_mA$ = mordanted with Alum, $_mCu$ = mordant with Coppersulphate, $_mCr$ = Mordanted with Potassium dichromate, $_mFe$ = mordanted with Ferrous sulphate, $_mT$ = premordanted with Tea, $_mPR$ = premordanted with pomegranate rind and D = Dye

The was fastness reading for Eri silk dyed with a combination of Madder and Ratanjot dye was between 4 and 4-5. This indicated that the wash fastness the composite dye on Eri silk fabric was good and higher than good, whereas Sisal fibre samples, dyed with composite dye showed good to excellent wash fastness. Eri silk and Sisal fibre samples were also tested for Dry and Wet rub fastness and it was observed that while the wet rub fastness was poor to average for silk fabric, it ranged between average to excellent in case of Sisal fibre. The lowest ranking was in the case of Eri silk fabric premordanted with Copper Sulphate with a rating between1-2 and the best rub fastness reading was obtained in case of Sisal fibre premordanted with copper sulphate and alum pretreated samples with fastness rating between 4-5. Fastness to light rating for 10 and 20 hours of exposure for Eri silk fabric yielded scores of fading to level 3 and darkening to level 5. For e.g. Eri silk sample treated only with myrobolan faded on exposure to light with a rating of 3 whereas samples with 4pH and 6pH showed darkening of shade. The dye failed to yield similar fastness to light with Sisal fibre as a substrate as the rating mostly ranged between 3 and 4 with and exception of samples pretreated with metallic mordants having better scores on fastness to light.

4.6 Value addition through natural dye and designing of products from minor fibres into four categories of home décor products.

New products made of unconventional/underutilized /minor fibres have become an emerging trend. "The transfer of experience of cotton sector had raised the utilization of jute fibres in hitherto unimagined end uses."[Saptarshi, L.V.] Jute fibre is now progressing toward a stage where its utilization has graduated from simple ropes and gunny bags to fancy packaging to fibre reinforced composites. Its utilization is also seen majorly in the carpet and rug industry and also in home décor and soft furnishing. This study was an effort to design products which would have a hand intensive approach rather than totally mechanized process so as to motivate small enterprise activity that will help in the proliferation and acceptance of the fibre products in Indian homes for décor purposes. Hence, low machine intensive, hand techniques were employed in order to design products and a variety of techniques were employed in order to explore multiple ways to enhance one fibre product. The following flow chart highlights the different techniques used in designing the products

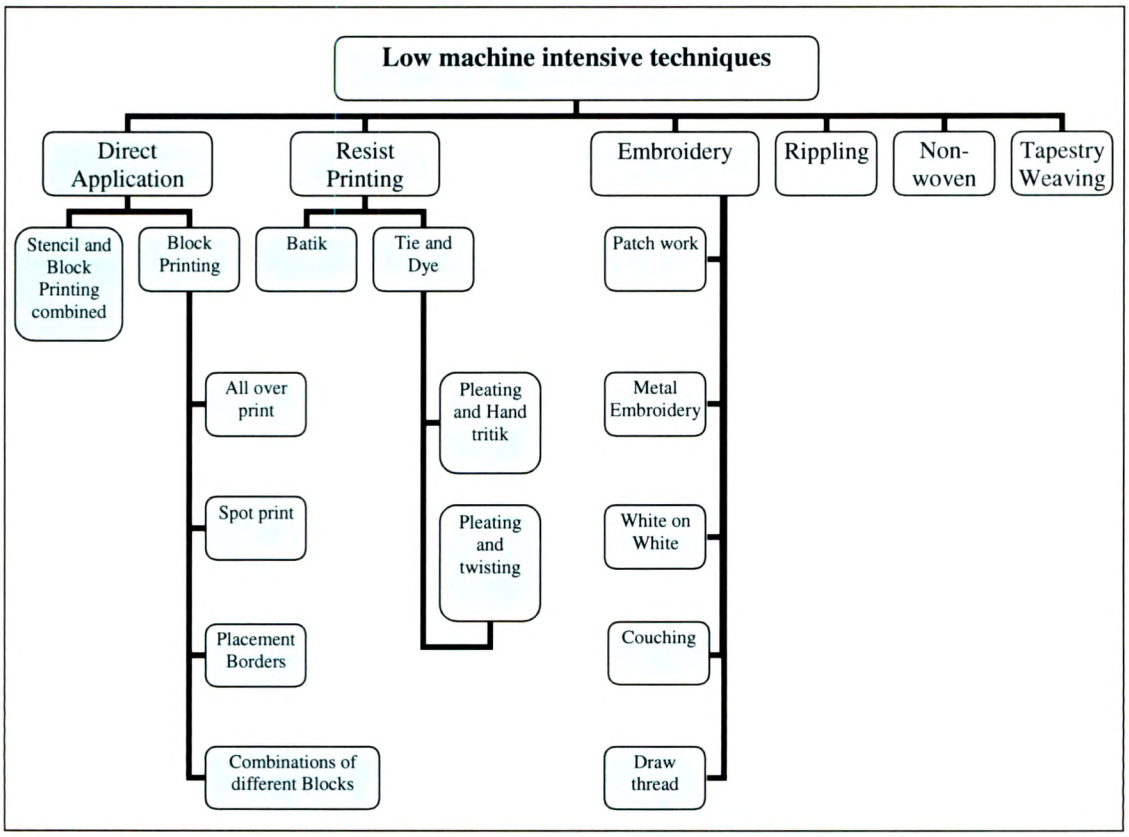


Figure 4.1: Flow Chart of techniques employed in designing products out of the selected four minor fibres.

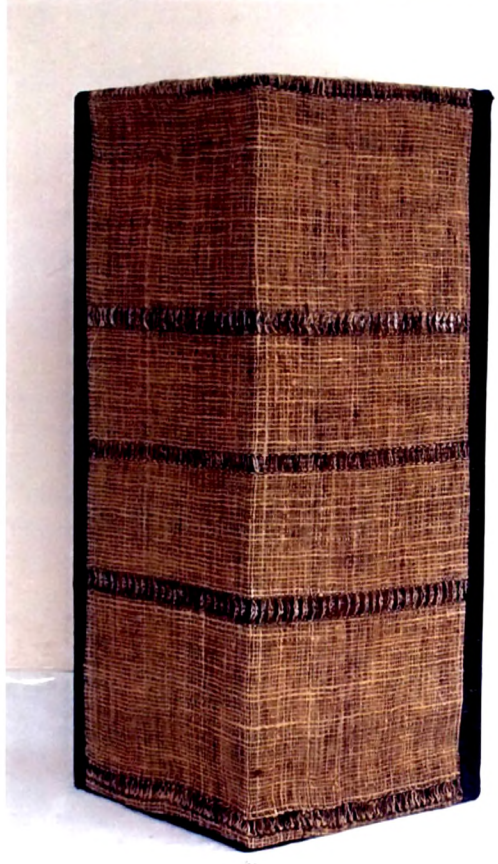
SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED PATANWADI GOAT HAIR LAMP SHADE

FIBRE TYPE: Patanwadi Goat Hair
PRODUCT: Lampshade
COST OF PRODUCT: 1268 Rs.
CONSUMPTION OF MATERIAL: 1.25 meter
TECHNIQUE: Fabric length of Goat hair fibre was dyed with XXX dye. The product intended was a lamp shade. Hence, keeping in mind the interplay of light and opacity the product was designed with dark and light regions. Draw thread technique was employed here in order to make openings for light to pass through from an otherwise coarsely woven material. Three rows of draw thread technique where the top and bottom employed one technique and centre had a different technique were employed.
DYES USED: Myrobolan pretreated wool fabric was first mordanted with natural mordant Tea and then dyed with Marigold dye.

Plate 4.10: Patanwadi Goat Hair Lamp Shade

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED PATANWADI GOAT HAIR FLOOR RUG

FIBRE TYPE: Patanwadi Goat Hair
PRODUCT: Floor Rug
COST OF PRODUCT: 2900 Rs.
CONSUMPTION OF MATERIAL: 5'x3' rug weighing 1.5 kg
TECHNIQUE: Goat hair is available in abundance in its natural colour black and in limited quantities in white. Hence, it was kept in mind that maximum use of the naturally available colour was to be made with value addition of the white fibres with natural dyes. Hence the Floor Rug was woven in the "Kharad" (Kutch style door mat), with a dominant use of natural black fibre and with fibres dyed with madder dye.
DYES USED: Madder with only Myrobolan as pretreatment.

Plate 4.11: Patanwadi goat hair floor rug

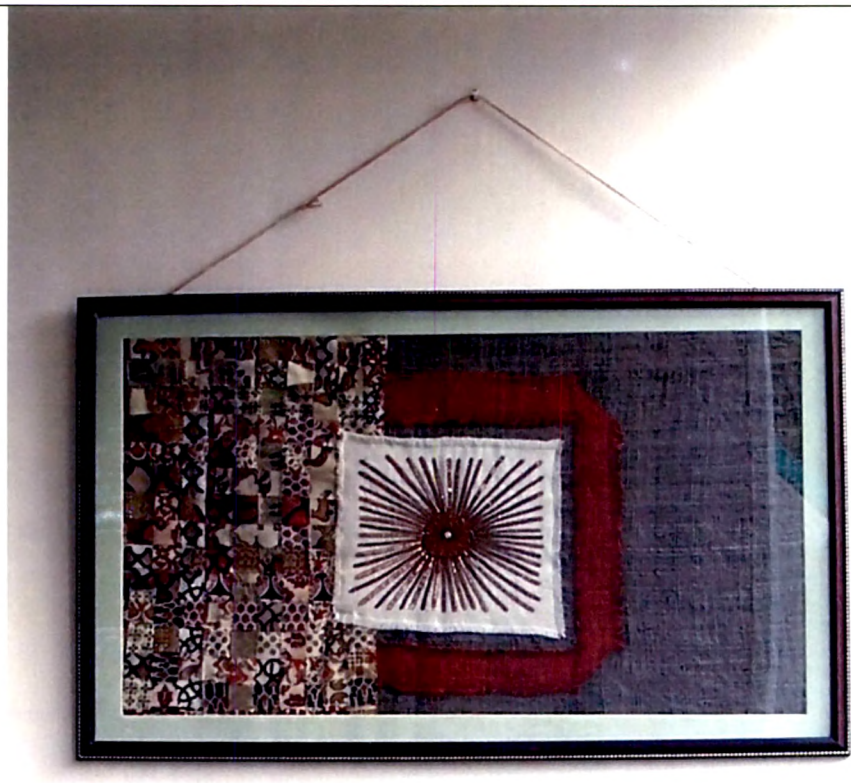
SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED PATANWADI GOAT HAIR WALL HANGING

FIBRE TYPE: Patanwadi Goat Hair
PRODUCT: Wall Hanging
COST OF PRODUCT: 1800 Rs.
CONSUMPTION OF MATERIAL: 1 meter
TECHNIQUE: Zardozi embroidered white goat hair fabric was employed as an accent to the subdued natural dyed patches of wool dyed with Ratanjot and Madder dye. In order to add an element of interest natural dye printed strips of cotton were matted and a part of the frame was created in order to employ visual interest to the frame. Care was taken that the cotton fibre material would contribute less than 25% of the total material share of the article made.
DYES USED: Ratanjot Dye at neutral pH, Madder dyed with Alum, natural dye printed cotton strips of mixed dyed like madder, Flame of forest, Ratanjot, etc.

Plate 4.12: Patanwadi goat hair wall hanging

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED PATANWADI GOAT HAIR PARTITION PANEL

FIBRE TYPE: Patanwadi Goat Hair
PRODUCT: Partition Panel
COST OF PRODUCT: 2700 Rs.
CONSUMPTION OF MATERIAL: 2.5 meter
TECHNIQUE: Tie and dye technique was used for making partition panels with patanwadi goat hair fabric. The fabric was first pleated into accordion pleats and then twisted and rolled into a ball and held inplace with cotton thread.and then taken for dyeing
DYES USED: Alum with ratanjot was used for the first panel and tea pretreated madder was used for the dyeing of the second panel

Plate 4.13: Patanwadi goat hair partition panel

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED ERI SILK LAMP SHADE

FIBRE TYPE: Eri Silk
PRODUCT: Lampshade
COST OF PRODUCT: 1890 Rs.
CONSUMPTION OF MATERIAL: 1.25 meter
TECHNIQUE: Eri silk fabric was block printed with ferrous acetate solution. Application of metal mordants was done into the patterned areas and the fabric was dyed with two dyes. Two facing panels were dyed with two different dyes in order to cut the monotony of colour with all four sides similar. The bottom edge of the lampshade was finished by employing tassels as an edge finish.
DYES USED: Two panels were treated with tea as a mordant and the other two were treated with pomegranate rind mordant. All the four panels were dyed with acacia catechu.

Plate 4.14: Eri silk lamp shade

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED ERI SILK FLOOR RUG

FIBRE TYPE: Eri silk
PRODUCT: Floor Rug
COST OF PRODUCT: 2760 Rs
CONSUMPTION OF MATERIAL: 1.25 meters
TECHNIQUE: Surface ornamentation by means of patchwork and white on white embroidery with white thread and transparent sequins was done.
DYES USED: Madder with Alum on the outer border, Madder with Copper Sulphate and Potassium dichromate in the Central Sun motif, Flame of Forest with Alum in the Central Yellow patch, mixed bag of the shades predominantly from marigold with metal mordants and natural mordants. Squares of samples premordanted with metal mordants and dyed with Acacia catechu, marigold and ratanjot were used.

Plate 4.15: Eri silk floor rug

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED ERI SILK WALL HANGING

FIBRE TYPE: Eri silk
PRODUCT: Wall Hanging
COST OF PRODUCT: 2615 Rs
CONSUMPTION OF MATERIAL: 2 meters
TECHNIQUE: Experimental Block Printing, here various blocks of different sizes were arranged and a print was taken in order to make a composition. The blocks were a part of the "jaali and yantra" collection of design at the Weavers Service Centre, Ahmedabad.
DYES USED: Madder with all ten premordanting combinations and outline printing and black solid fill with Ferrous Acetate.

Plate 4.16: Eri silk wall hanging

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED ERI SILK PARTITION PANEL

FIBRE TYPE: Eri silk
PRODUCT: Partition Panel
COST OF PRODUCT: 3618
CONSUMPTION OF MATERIAL: 2 meters
TECHNIQUE: Creating an allover surface print by block printing. Four surface were developed with an all over surface print. Metal mordants alum, copper sulphate potassium dichromate and ferrous sulphate were printed on the surface of the panels and allowed to dry. The fabric was washed in running water and then developed into dyes.
DYES USED: Marigold, Madder, Acacia catechu, Henna

Plate 4.17: Eri silk partition panel

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED SISAL FIBRE LAMP SHADE

FIBRE TYPE: Sisal Fibre
PRODUCT: Lamp shade
COST OF PRODUCT: 1775 Rs.
CONSUMPTION OF MATERIAL: 1.25 meter
TECHNIQUE: Multi coloured sisal fibres were braided and then couched on the base fabric with golden thread. The lampshade is cylindrical in nature with a diameter of six inches and two feet tall
DYES USED: Base fabric: Marigold at 6pH, couched braids mixed palette from all the dyeing experiments.

Plate 4.18: Sisal fibre lamp shade

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED SISAL FIBRE FLOOR RUG

FIBRE TYPE: Sisal Fibre
PRODUCT: Floor Rug
COST OF PRODUCT: 1615 Rs
CONSUMPTION OF MATERIAL: 1.25 meter
TECHNIQUE: Batik printing with a paraffin:bees wax ratio of 60:40 was used. Wax application was done on both sides of the fabric as the fabric was thick in nature. The dyed samples were then dyed in a bath at 60°C for half an hour and then dewaxed washed and dried.
DYES USED: Marigold at 4pH for the fishes, Acacia Catechu with Copper sulphate for the chevron pattern and at 8pH for border, edge finishing with bias binding done with cotton fabric dyed with ferrous acetate.

Plate 4.19: Sisal fibre floor rug

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED SISAL FIBRE WALL HANGING

FIBRE TYPE: Sisal Fibre
PRODUCT: Wall Hanging
COST OF PRODUCT: 1323 Rs
CONSUMPTION OF MATERIAL: 0.5 meter
TECHNIQUE: Patch work with Sewing machine, recreated look inspired from worli paintings with red mud wall and white geometric figurines.
DYES USED: Madder and Ratanjot dye mixture was used as the main background of the fibre. The bottom panel was dyed with a composite mixture of flame of forest and madder dye. The human figurine patches worked out were inspired from worli paintings. The patchwork was done with the help of an automatic sewing machine with white thread.

Plate 4.20: Sisal fibre wall hanging

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED SISAL FIBRE PARTITION PANEL

FIBRE TYPE: Sisal Fibre
PRODUCT: Partition Panel
COST OF PRODUCT: 3100 Rs
CONSUMPTION OF MATERIAL: 200 grams
TECHNIQUE: Multi-coloured sisal fibre web simulating a non-woven fabric.
DYES USED: Colours derived from composite dyeing experiments of Madder Marigold, Madder Ratanjot, Madder Flame of Forest

Plate 4.21: Sisal fibre partition panel

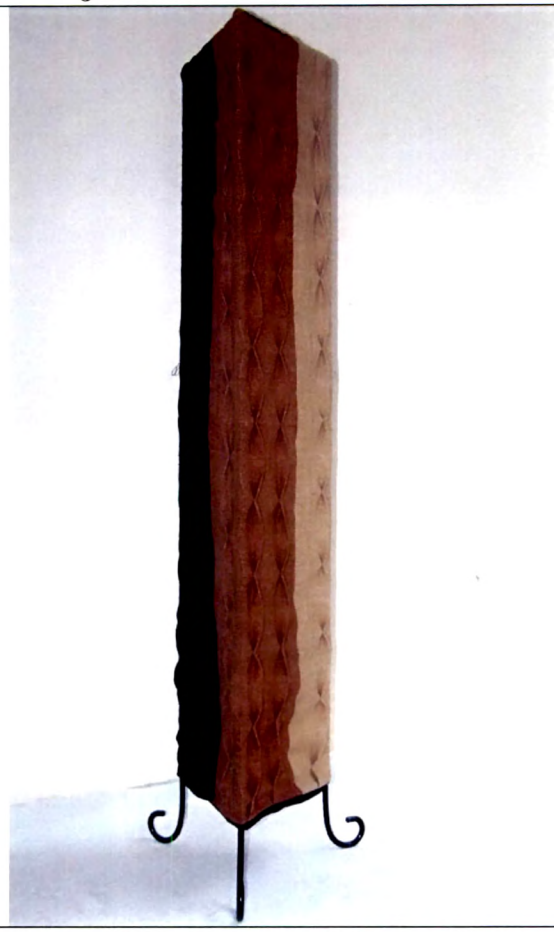
SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED JUTE FABRIC LAMPSHADE

FIBRE TYPE: Jute
PRODUCT: Lamp shade
COST OF PRODUCT: 2150 Rs.
CONSUMPTION OF MATERIAL: 3 meters
TECHNIQUE: Textured surface by means of stitching pleats in alternate directions, this method is called rippling.
DYES USED: Acacia catechu dyed at 6pH, copper sulphate and ferrous sulphate

Plate 4.22: Jute lamp shade

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED JUTE FABRIC FLOOR RUG

FIBRE TYPE: Jute
PRODUCT: Floor Rug
COST OF PRODUCT: 1300 Rs.
CONSUMPTION OF MATERIAL: 1.25 meter
TECHNIQUE: Stencil printing and Block printing
DYES USED: Madder and Ratanjot dye mixture was used for the borders with alum, copper sulphate and potassium dichromate printed as mordants, the central panel is developed with Flame of Forest dye

Plate 4.23: Jute floor rug

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED JUTE FABRIC WALL HANGING

FIBRE TYPE: Jute
PRODUCT: Wall Hanging
COST OF PRODUCT:
CONSUMPTION OF MATERIAL: 1.5 meter
TECHNIQUE: Tie and Dye method with pleating and hand tritik technique.
DYES USED: Alum pretreated jute fabric dyed with Ratanjot dye

Plate 4.24: Jute wall hanging

SPECIFICATION SHEET OF NATURAL DYE VALUE ADDED JUTE FABRIC PARTITION PANEL

FIBRE TYPE: Jute
PRODUCT: Partition Panel
COST OF PRODUCT: 2980 Rs
CONSUMPTION OF MATERIAL: 3 meter
TECHNIQUE: Block printed jute fabric dyed with six natural dyes. The partition panel has identical front and back sides. The rectangular block printed natural dyed block could be arranged in a checkered pattern. Change in the sequence of colour could be made by sliding the rod and changing the placement of the fabric pieces which easily slide into the rod.
DYES USED: Madder, Marigold, Flame of forest, Henna, Ratanjot and Acacia catechu

Plate 4.25: Jute Partition panel

Plate 4.26: A range of home décor products designed out of Goat Hair

Plate 4.27: A range of home décor products designed out of Jute fabric

Plate 4.28: A range of home décor products designed out of Eri silk fabric

Plate 4.29: A range of home décor products designed out of Sisal fibre fabric

4.7 Results of the Consumer responses for the natural dyed products.

The natural dye value added products fashioned out of four underutilized fibres were exhibited at two cities. Opinions regarding the awareness of concepts like environment friendly process and products, the need for such products and the non availability of the products were elicited through a questionnaire administered to a random sample of 485 respondents. The responses were then coded and evaluated through suitable statistical methods.

Table 4.29: Demographic profile of the respondents for the study (N=485)

Demographic detail		Number of respondents
Age in years	21 – 25	87
	26 – 30	48
	31 – 35	78
	36 – 40	97
	41 – 45	87
	46 and above	87
Educational qualification	Graduate	213
	Post Graduate	243
	Ph.D.	29
Monthly Family Income	Rs10,000-20,000	29
	Rs.20,001-30,000	116
	Rs.30,001-40,000	155
	Rs.40,001-above	136

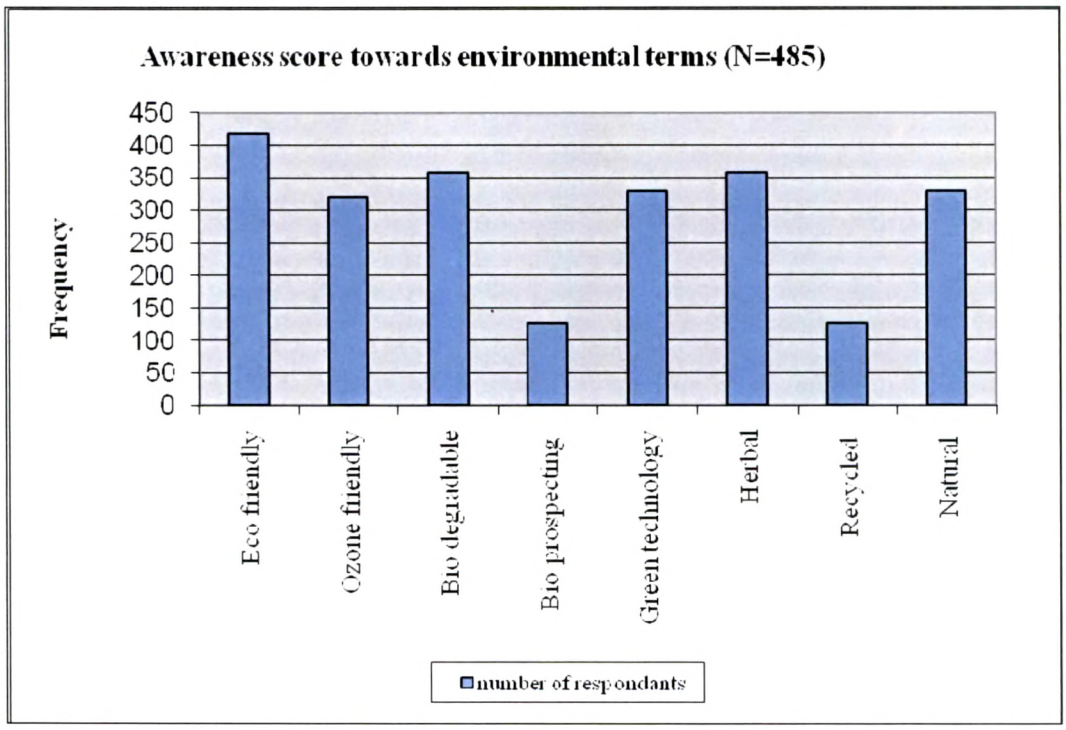
The demographic profile of the respondents indicated that out of a sample of 485 respondents, 20 percent of the respondents belonged to the age group of 36 – 40 years. The age groups 21 – 25, 41 – 45 and 46 years each had 17 percent respondents. 16 percent respondents belonged to the age group 30 – 40 and 9.8 percent respondents were from age group 26 – 30 years. Hence, it could be observed that all the 6 age groups had almost equivalent distribution of the sample with an exception of age group 26 - 30.

The 50 percent of the respondents had received post graduate level education. Out of the rest, 44 percent had undergone graduate studies and only 6 percent of the

respondents had pursued a doctorate degree. The criterion for purposively admitting graduate level respondents was upon logic that an educated respondent would have awareness towards concepts like eco-friendliness and sustainability.

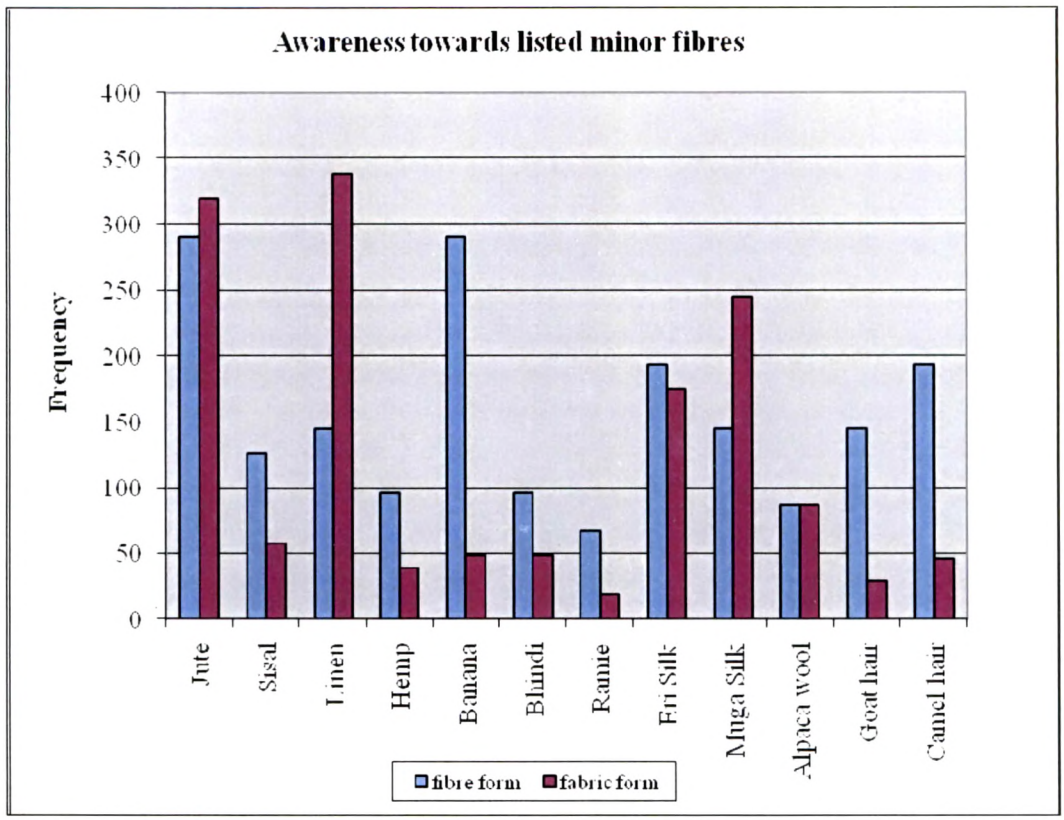
58 percent of the population belonged to the homemaker and student category where a tangible contribution to the family income is either nil or insignificant. But 18 percent of the respondents were employed to the salaried means of income generation and 24 percent of the sample contributed to the family income by self employment.

A range of 10,000-20,000, 20,001 – 30,000, 30,001 – 40,000, 40,001 – above, were made in order to categorize respondents according to the family income group. 6%, 24%, 32% and 28% was the percentage distribution across each range respectively. The distribution of respondents indicated that a majority of the respondents belonged to the higher income groups. 60 percent of the respondents were married and 40 percent were unmarried.



Graph 4.10: Scores of respondents for awareness towards environmental terms

All the respondents were aware of terms like eco-friendly, ozone friendly, bio-degradable, bio-prospecting, green technology, herbal, recycled and natural in various degrees. The scores obtained are indicated in the graph.



Graph 4.11: Score of respondents towards awareness of listed minor fibres

It was observed that all the respondents were aware of the various minor fibres that were listed in the questionnaire. Note worthy observations were that respondents said that they have jute in the form of fibre and fabric and 30 percent of the respondents said that they possessed an item made of jute fibres. The items listed were mostly bags with 11 respondents saying that they possessed a jute rug. One of the respondents listed the possession of a sisal bag, and only 12 percent of the respondents said that they have seen sisal in fibre or fabric form. The highest score was obtained for linen fabric where 24 percent of the respondents said that they possessed an apparel item made out of this fibre. And the second highest was Muga Silk where 21 percent possessed either a saree or *mekhla chadar* made of Muga silk. Two percent of the population possessed sweater or shawls made out of alpaca wool and 3 percent of the respondents wrote of possessing footwear or bag fashioned out of camel hair. 3.5% of the population said that they possessed shawls of eri silk fabric. Hence, it was concluded that out of the various minor fibres listed in the questionnaire

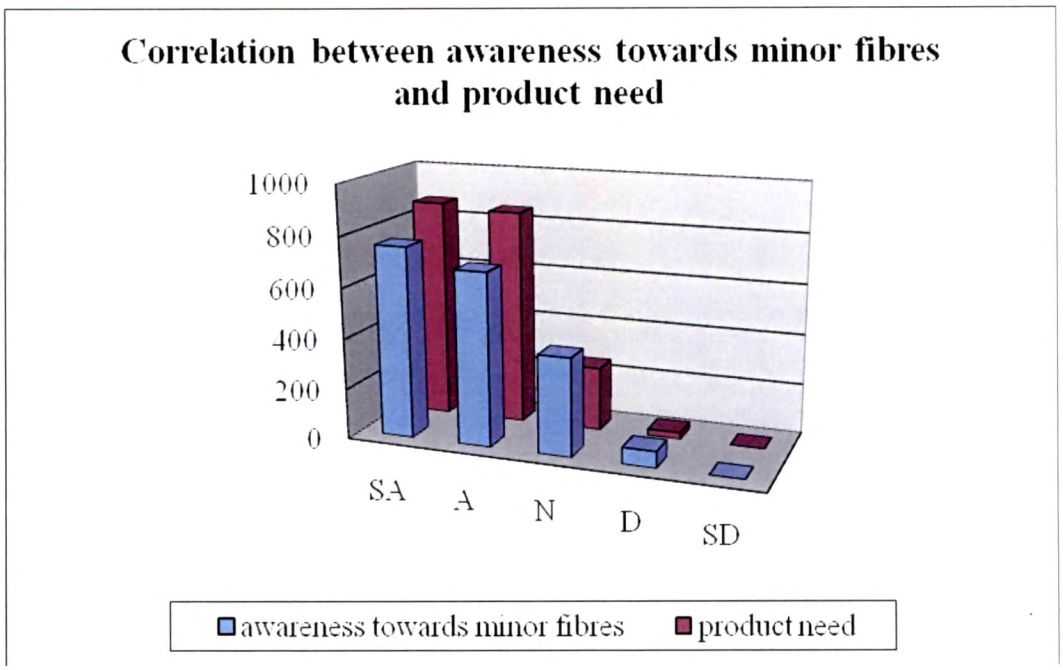
jute rugs were the only item that belonged to the home décor category and rest of the items belonged to the apparel and accessory items of utility. None of the respondents possessed any item made out of goat hair and it was stated that only 30 percent had seen goat hair in fibre form and 6 percent in fabric form. This indicated that in spite of the availability and awareness of the existence of fibre; the utility of the fibre is mostly limited. As observed, most of the respondents either possess a craft item, or a traditional costume or bags and accessories made out of the minor fibre but utility of these fibres in home décor appears to a very small extent. This is an indicator that when asked about the need for more minor fibre products for home décor, the responses should indicate a positive trend towards an existing need for unconventional fibre products for home decor.

Out of a total number of 485 respondents 436 indicated that the products were unique because of the colour, 417 agreed that the fibres used were unique and 407 liked the techniques adapted in the making of the products. It was hence indicated that the acceptance of the products was more due to the colour and fibres and then the techniques.

The scores 262, 407 and 165 were obtained for elite, upper-class and middle class respectively when respondents were asked to express their opinion about the suitability of the natural dyed minor fibre products to the home of a particular strata of the society. This indicated that most of the respondents felt that the products were fit for consumption for upper and elite home decors and then the middle class.

Table 4.30: Correlation between awareness and need for minor fibre products of the respondents (Average weighted scores)

Responses	Awareness towards minor fibres	Need for products designed using minor fibres
Strongly Agree	758.3333	871.6667
Agree	685.3333	852
Neutral	388	252
Disagree	64.66667	25.33333
Strongly Disagree	0	0
r = 0.976051		

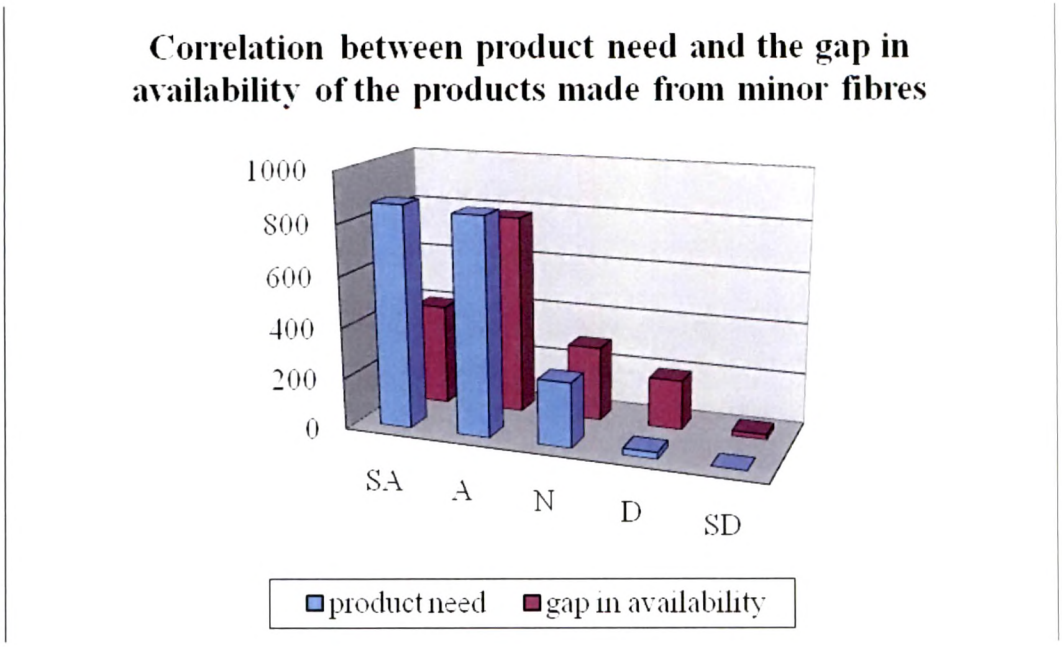


Graph 4.12: Correlation between awareness towards minor fibres and product need

It was observed from the graph that the trend line of awareness and that of product need coincide to a good degree of similarity. It indicated that a positive score towards awarness generated and equally positive score towards the felt need for certain eco friendly minor fibre products. The coefficient of correlation r = 0.976051 indicated, that there was a strong positive correlation between awareness and need of eco friendly products presented in the exhibition.

Table 4.31: Correlation between product need and gap in availability of minor fibre products (Average weighted scores)

Responses	**Average weighted scores of product need**	**Average weighted scores of gap in availability**
Strongly Agree	871.6667	397.6667
Agree	852	782
Neutral	252	291
Disagree	25.33333	193.3333
Strongly Disagree	0	19.66667
r = 0.845603		

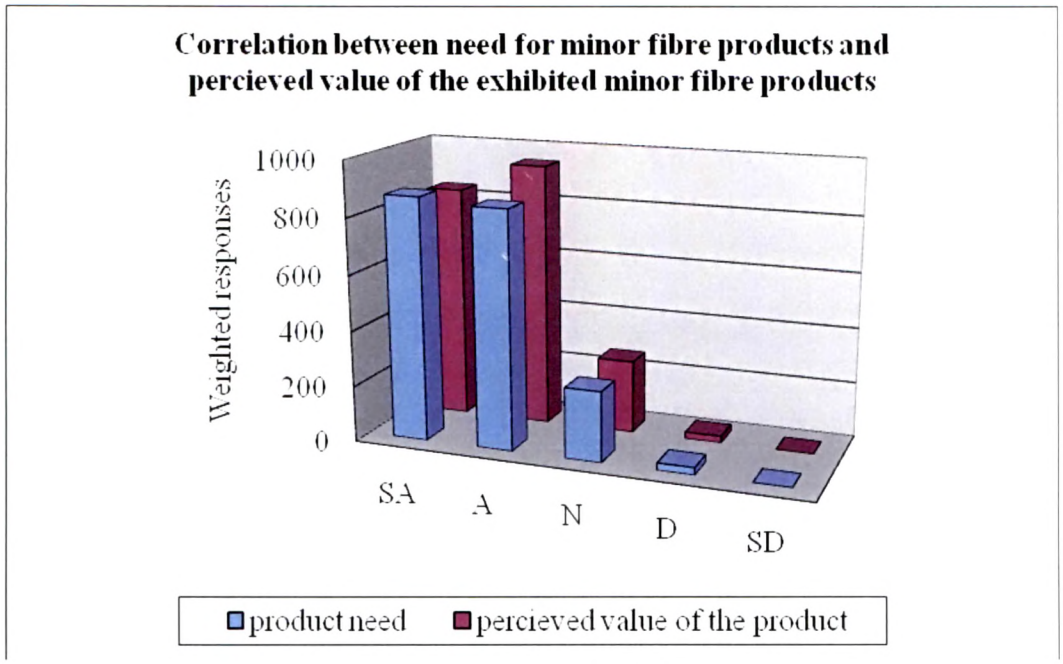


Graph 4.13: Correlation between product need and gap in availability of the products made from minor fibres

According to the Table 4.31 coefficient of correlation r = 0.845603 indicated that there was a positive correlation between the felt need of the product and the gap in availability of the product. It indicates that a majority of the respondents agreed to the statements that they frequently face a situation where they do not get the material they had asked for.

Table 4.32: Correlation between product need and perceived value of minor fibre products (Average weighted scores)

Responses	**Product need**	**Perceived value of the product**
Strongly Agree	871.6667	840
Agree	852	944
Neutral	252	262
Disagree	25.33333	23.33333
Strongly Disagree	0	0
r = 0.995207		

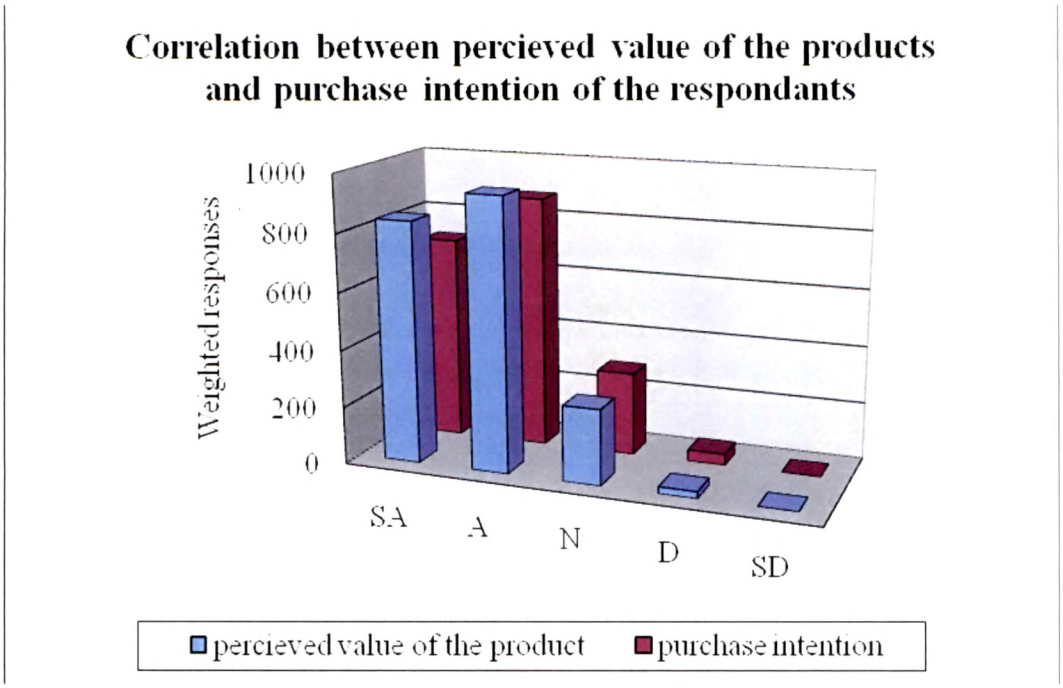


Graph 4.14: Correlation between need for minor fibre products and perceived value of the exhibited minor fibre products

The value of correlation coefficient r indicates a high degree of correlation between the product need and perceived value of the exhibited products. It is observed form the above graphs 4.14 that awareness towards the environment and eco friendly products, relate positively with the need for eco friendly product and also that there was a positive correlation between need and gap in availability of products. The respondents also indicated that the exhibited products do fetch more value to them due to the newness of the fibres which are value added by means of natural dyeing. Hence, there was a high perceived need / existing market opportunity waiting to be tapped in the area of natural dyed value added products.

Table 4.33: Correlation between perceived value of the minor fibre products to purchase intention of the respondents (Average weighted scores)

Responses	**Average weighted scores of perceived value of the product**	**Average weighted scores of purchase intention of the respondents**
Strongly Agree	840	711.6667
Agree	944	878.6667
Neutral	262	290
Disagree	23.33333	39
Strongly Disagree	0	0
r = 0.996015		



Graph 4.15: Correlation between perceived value of the products and purchase intention of the respondents

A high degree of correlation existed between perceived value of the product and purchase intention as the correlation coefficient was 0.99.

Table 4.34: Correlation between purchase intention and availability of the products through Handloom and Handicrafts outlets.

Responses	**Average weighted scores of purchase intention**	**Average weighted scores of availability through handloom and handicraft outlets**
Strongly Agree	711.6667	190.6667
Agree	878.6667	336.6667
Neutral	290	295.6667
Disagree	39	49.33333
Strongly Disagree	0	61.66667
r = 0.772766		