

A Study on Silk Fabric Applied with Eco-Friendlycolorants for the Enhancement of Textile Properties

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Abstract. Silk is possessed with valuable textile materials of unique properties like sheen, softness, luster, elegance, strength, uniformity make it suitable for the production of unique textile and garment products. Compared to other textiles like cotton; silk consists of the functional groups in different aspects suitable in the application of both the acid and the basic mild conditions. Hence, silk could be subjected with the coloration process using various dye categories. With respect to this, it is proposed in the present work to increase the characteristics of domestic mulberry silk fabric by treating with collected sericin along with natural finishing sources like aloe vera, amla and nochi in varied combinations followed by coloring process using some specific natural sources. The silk fabrics were then subjected for some specific testing process for measuring the coloration data, fastness characters, hand values, absorption criteria, UV protection aspects, X-ray diffraction micrographs and scanning electron microscope images. The results received are in the satisfaction level suitable for the production of textile products especially garment and apparels.

Keywords: Silk Fabric, Eco Friendly colorants, Textile.

1 Introduction

The two families which spin silk fiber are *Saturnidae* and *Bombycidae*. *Bombyx mori* which belongs to *Bombycidae* produces the soft and delicate dual threads of protein called fibroin. The protein in silk is an essential constituent of the filament possessed in cocoon similar to that of the keratin, collagen, sporgin, and elastin [1-3]. The silk comprised of fiber protein is synthesized by the gland cells stored in the lumen. The silk fibers constitute protein - 97%, in that fibroin is a fiber protein in filament form and sericin – a gum is considered as non fibrous protein. In addition, other unlike components such as carbohydrates, wax, inorganic salts and pigments are also present [3-5]. Sericin is insoluble in cold water but easily hydrolyzed in an alkaline medium. The presence of sericin in silk fiber increases the strength, reduces the luster and hence in order to enhance the luster the raw silk must be degummed prior to dyeing [4,6]. Silk filament and fiber find use in many products like industrial fabrics, medical sutures, aero-parachutes, tire-lining materials, and also artificial-blood vessels [5, 7].

The softness, the translucence, as well as the smoothness revealed by the purified silk is with regard to their varied extents of intermittent transmittance, smooth surface reflections

as well the diffused and reflected light. Many studies of the research workers by use of x-ray techniques on silk related the properties namely handle, luster, brightness with its crystal structure [6,8,9]. In spite of all these inherent properties of silk, in this research work it is proposed to treat the raw mulberry silk fabric for degumming to collect sericin which was used for the application along with selected natural sources such as aloevera, amla and nochi in different combinations followed by the coloration with some listed natural sources like that of the Madder, Red Sandal Wood, Barberry, Annatto, Myrobalan, Pomogranate, Onion, and Grape. Finally, from this research work, the results received were convincing corresponding to the possibility of utility in the textile and garment product purposes.

2. Materials & Methods

2.1 Materials

The raw mulberry silk fabric - 100%, Woven, plain - was collected from the Gandhipuram Sharvodaya Sangh (Vadavalli, Coimbatore, Tamil Nadu, India). The specifications involved for the raw silk fabric are as: warp and weft count 2 / 80's respectively, ends / inch 100, picks / inch 60, G S M 95, and cloth width 44 inches.

The original natural resources, namely; 1) madder, 2) red sandal wood, 3) barberry, 4) annatto, 5) myrobalan, 6) pomogranate, 7) onion, and 8) grape as well as I) Aloevera, II) Amla, and III) Nochi are collected from the Forest Department (Coimbatore, Tamil Nadu, India).

The selected original natural sources; Madder, Red Sandal Wood, Barberry, Annatto, Myrobalan, Pomogranate, Onion, and Grape are utilized for the purpose of coloration. Whereas, Aloevera, Amla, and Nochi are involved for improving the functional application purposes in addition to the recovered Sericin (Protein) obtained from the raw silk fabric; individually as well as in the combination of them over the silk fabric with the coloring natural sources.

The selected chemicals & auxiliaries noted in this study elsewhere for the treatments are purchased in the A R grade.

2.2 Methods

2.2a. Raw mulberry silk fabric treatment

A treatment of 10-gpl HCl was applied on the mulberry (raw) silk fabric for sixty minutes in the respective baths separately with the material to liquor ratio-MLR of 1:30 at around 40°C for the removal of the natural and added unwanted-impurities. The process of degumming was then carried out by sodium carbonate 2% on weight of material (owm) & commercial soap powder for degumming (2% owm) at around 85°C for nearly two hours. Finally, the silk fabric was washed thoroughly using de-ionized water and dried completely [10-12].

2.2b. Collection of sericin from the degum bath

The degumming solution was collected safely, preserved and then subjected for the purification in order to recover the sericin, as per the established technique [13, 14].

2.2c. Process of extraction from natural sources

The extraction process as preferred by the established standard methods were incorporated on the selected natural sources namely Madder, Red Sandal Wood, Barberry, Annatto, Myrobalan, Pomogranate, Onion, Grape, Aloevera, Amla, and Nochi [15,16].

2.2d. Process of coloration and K/S value determination

The natural sources extracted for coloration were applied on the silk fabrics, which were treated already with the functional category of natural sources (aloevera, amla, nochi and extracted protein) in differed aspects for the improvement of natural coloration and finishing values in the following manner:

0 – without any treatment ; a – with recovered protein ; b- aloevera with protein

c- amla with protein d- nochi with protein

A - Protein with (aloevera and amla); B - Protein with (Aloevera and Nochi) C- Protein with (Amla and Nochi); D - Protein with (Aloevera, Amla and Nochi)

The silk fabrics were colored by the established standard technique with the extracted natural sources of the concentration of 25 gram per litre at nearly boil temperature for two around hours with the MLR of 1:30. The color strength value (K/S) was then calculated with the help of Kubelka-Munk relation, represented as; $K / S = ((1-R)^2/2R)$ [17-21].

2.2e. Measuring the fastness property values on the natural colored silk fabrics

The natural colored silk fabrics were subjected with established standard AATCC test methods for the measurement of fastness properties (like wash, light, and rubbing) based on the techniques of 61-1996, 2003; 16-1998, 2003; 8-2007, 2007; 135-1985, 2003 respectively [22-25].

2.2f. Measurement of the objective assessment on the natural colored silk fabrics by KES-F

The hand properties with respect to the mechanical and surface properties of the natural colored silk fabrics were measured by the Kawabata evaluation system (KES-F) [26].

2.2g. Measurement of the air and water vapor permeability of natural colored silk fabrics

The ASTM D737 was used for measuring the air permeability; and the ASTM E96 moisture vapor test was used for measuring the WVP rate of the natural colored silk fabrics [27,28].

2.2h. Measurement of the UPF assessment in the natural colored silk fabrics

According to the standard established method, the silk fabric was subjected with uv protection finishing (Super FX Anti UV) and tested based on the requirement [29,30].

2.2i. Test for the XRD of natural colored silk fabrics

In the natural colored silk fabrics, the unknown crystalline materials present were determined using XRD (Shimadzu XRD6000) technique [31,32].

2.2j Test for the SEM of the natural colored silk fabrics

The colored silk fabrics were undergone for the scanning-electron-microscope study using the 30-kV scanning-electron-microscope (JEOL-Japan, Model J S M – 6360) [33,34].

3. Results And Discussion

3.1. Colorimetric and color fastness data of the natural colored silk

3.1a. Color value of the natural colored silk

The color values of the natural sources such as; Madder, Red Sandal Wood, Barberry, Annatto, Myrobalan, Pomegranate, Onion, and Grape, natural colored on silk fabric applied with sericin (protein), aloe vera, amla, nochi in different combinations are shown in the Table 1a. It is noted from the Table 1a that the silk fabric gets good colors in the manner of Red, Orange-Red, Yellow, Orange, Green, Brown, Red Orange and Purple as colored using the help of natural sources such as Madder, Red Sandal Wood, Barberry, Annatto, Myrobalan, Pomegranate, Onion, and Grape. It is also observed from this table, the treated (0, a, b, c, d) silk fabrics dyed with natural sources show the least colorimetric data compared with those of the other treated (A, B, C, D) silk fabrics. Sericin - protein was applied on silk fabrics with aloe vera, amla, nochi individually as well as in combination with the each other. It is evidenced that, among all these treated silk fabrics, the colorimetric data is maximum for those applied with sericin with aloe vera, amla and nochi and least in the case of sericin treated only fabrics. From the Table 1a, it is evident that the presence of aloe vera enhances the colorimetric data considerably. In the silk fabric treated with aloe vera and nochi along with the protein, it is seen that there is a remarkable increase in the colorimetric data.

Kubelka–Munk theory is used as the most common approach to the optical properties of the substrate and colorant. As the opaque material surfaces are exposed to the light then the reflection, absorption and scattering occur. The reflectance shown by the colored textile substrate as the value of an absorption-spectrum, $K(\lambda)$ and a scattering-spectrum of the textile substrate $S(\lambda)$ is described by the source light interacting with a textile fiber substrate which reveals the absorption/scattering of light by the respective colored molecules and the textile fibers. Hence, the behavior of a dye can be predicted at a given concentration, due to the fact that the colorimetric data can be found at various wavelengths.

3.1b. Color fastness data of the natural colored silk

The color fastness values like wash, light, and rub fastness properties of natural colored silk fabrics applied with sericin, aloe vera, amla and nochi in different combinations are also shown in Table 1b. It is noted from the table that the overall fastness properties are maximum for the silk fabrics with all the combined treatment, however they are least for the natural colored silk fabrics without any treatment. There is moderate to good trend in the general fastness properties on all the treated and natural colored silk fabrics, but still in all the cases, the wet rubbing fastness is considerably less. The fastness property values exhibited by the silk fabrics natural colored with annatto, myrobalan and pomegranate are relatively good. AATCC defines the color fastness as the resistive force of a textile fiber substrate to change in any of the color characters, to transfer the colorant(s) to the nearby textile substrates, or in

both, with regard to the exposure of the textile material to any reliable condition which may be met in the textile processing, testing, storage, or in the use of textile products. In general, it is mentioned as the capability to contain the color throughout the life cycle. Also, in textile testing, varied types of colorfastness characters that are assumed to give the end users with an anticipated product.

Table 1a. Colors obtained and colorimetric data on the natural colored silk

Natural sources & Colors obtained			Color values								
Natural Sources	Botanical Name	Colors Obtained	0	a	b	c	d	A	B	C	D
i) Madder	<i>(Rubiacardi folia)</i>	Red	12.7	12.8	13.3	13.0	13.2	13.5	13.4	13.4	13.6
ii) RS Wood	<i>(Pterocarpus santallinus)</i>	Orange red	12.6	12.9	13.4	13.1	13.3	13.6	13.7	13.5	13.8
iii) Barberry	<i>(Berberis vulgaris)</i>	Yellow	12.3	12.9	13.5	13.2	13.3	13.6	13.7	13.6	13.8
iv) Annatto	<i>(Bixa orellana)</i>	Orange	13.0	13.1	13.5	13.2	13.4	13.7	13.7	13.6	13.9
v) Myrobalan	<i>(Terminalia chebula)</i>	Green	12.4	12.7	13.3	12.9	13.1	13.6	13.7	13.5	13.8
vi) Pomogranate	<i>(Punica granatum)</i>	Brown	12.9	13.2	13.6	13.3	13.5	13.7	13.8	13.7	13.9
vii) Onion	<i>(Allium cepa)</i>	Red orange	12.8	12.9	13.4	13.1	13.3	13.6	13.7	13.5	13.8
viii) Grape	<i>(Citrus paradise)</i>	Purple	12.5	12.7	13.4	12.9	13.1	13.5	13.7	13.4	13.8
Mean			12.7	12.9	12.7	12.9	13.4	13.1	13.3	13.6	13.7
Standard Deviation			0.19	0.17	0.19	0.17	0.09	0.14	0.13	0.07	0.11
Variance			0.04	0.03	0.04	0.03	0.01	0.02	0.02	0.01	0.01

RS Wood Red Sandal Wood

0 – without any treatment ; a – with recovered protein ; b- aloevera with protein

c- amla with protein d- nochi with protein

A - Protein with (aloevera and amla); B - Protein with (Aloevera and Nochi) C- Protein with (Amla and Nochi); D - Protein with (Aloevera, Amla and Nochi)

Table 1b. Color fastness data of the natural colored silk

S. No.	Wash fastness									Light fastness								
	0	a	b	c	d	A	B	C	D	0	a	b	c	d	A	B	C	D
i	2-3	3	3-4	3-4	3-4	3-4	3-4	3	3-4	3-4	3-4	4	4	4	4	4	4	4-5
ii	2-3	3	3	3	3	3	3	3	3-4	3	3-4	3-4	3-4	3-4	3-4	4	3-4	4

iii	3	3	3-4	3	3	3	3-4	3	3-4	3-4	4	4	4	4	4	4	4	4	
iv	2-3	3	3-4	3	3-4	3-4	3-4	3-4	3-4	4	3-4	3-4	4	3-4	4	4	4-5	4	4-5
v	3	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	4	4	4	4	4	4	3-4	4-5	
vi	3	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	4	3-4	4	4	4	4	4-5	4	4-5	
vii	3	3	3	3	3	3	3	3	3-4	3	3-4	4	3-4	3-4	4	4	3-4	4	
viii	2-3	3	3	3	3	3	3	3	3	3	3-4	3-4	3-4	3-4	3-4	3-4	3-4	4	
M	2-3	3	3-4	3	3	3	3	3	3-4	3	3-4	3-4	3-4	3-4	3-4	4	3-4	4	
SD	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.4	0.4	0.5	0.5	
V	0.1	0.1	0.3	0.1	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0.2	0.3	
S.	Rub fastness																		
No.	0		a		b		c		d		A		B		C		D		
	w	d	w	d	w	d	w	d	w	d	w	d	w	d	w	d	w	d	
i	2	2	2	3	2	3-4	2	3	2	3	2	3	2-3	3-4	2	3	2-3	4	
ii	2	2	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2-3	3-4	
iii	2	2-3	2-3	3	2-3	3	2-3	3	2-3	3	2-3	3	3	3	2-3	3	3	3-4	
iv	2	3	2-3	3	2-3	3	2-3	3	2-3	3	3	3-4	3	3-4	2-3	3	3	3-4	
v	2	2	2	3	2-3	3-4	2	3	2-3	3-4	2-3	3-4	2-3	3-4	2-3	3-4	2-3	3-4	
vi	2	2-3	2	3	2-3	3-4	2-3	3-4	2-3	3-4	3	3-4	3	3-4	2-3	3-4	3	4	
vii	2	2	2	3	2-3	3	2	3	2	3	2	3	2-3	3	2	3	2-3	3-4	
viii	2	2	2	2	2	2	2	2	2	2	2	2	2	2-3	2	2	2-3	3	
M	2	2	2	2-3	2	3	2	3	2	3	2	3	2-3	3	2	3	2-3	3-4	
SD	0	0.46	0.35	0.35	0.52	0.54	0.46	0.54	0.46	0.54	0.52	0.64	0.52	0.52	0.46	0.54	0.46	0.52	
V	0	0.21	0.13	0.13	0.27	0.29	0.21	0.29	0.21	0.29	0.27	0.41	0.27	0.27	0.21	0.29	0.21	0.27	

M Mean; SD Standard Deviation; V Variance w – Wet; d - Dry

i) Madder; ii) RS Wood ; iii) Barberry ; iv) Annatto ; v) Myrobalan ; vi) Pomogranate
vii) Onion ; viii) Grape

3.2 KES-F data of natural colored silk

The KES-F data of natural colored silk fabrics are shown in Tables 2b with respect to the standard descriptions given in the Table 2a. The details regarding the hand values with respect to smoothness, stiffness and fullness of the natural colored silk fabric are presented in the Table 2b. When the combination of finishing treatment using recovered protein with other natural finishing sources increases, in different combined form the smoothness and fullness increases and stiffness decreases correspondingly after coloration with natural sources compared with those of the untreated natural colored silk fabric as evidenced in the Table 2b.

Table 2a. KES-F data of natural colored silk

Common description	(Unit)
Tensile^a	
1) LT - Linearity of Load/extension curve (None)	
2) WT - Tensile energy (N/m)	
3) RT - Tensile resilience (%)	

Bending^a 4) B - Bending rigidity (10 ⁻⁴ Nm) 5) HB - Hysteresis of bending moment (10 ⁻² N)
Shearing^a 6) G - Shear stiffness (N/m Deg.) 7) HG - Hysteresis of shear force at 0.5° of shear angle (N/m) 8) HG5 - Hysteresis of shear force at 5° of shear angle (N/m)
Compression 9) LC - Linearity of compression/thickness curve (None) 10) WC - Compressional energy (N/m) 11) RC - Compressional resilience (%)
Surface^a 12) MIU - Coefficient of friction (None) 13) MMD - Mean deviation of friction (None) 14) SMD - Geometrical roughness (µm)
Construction 15) T - Fabric thickness (Mm) 16) W - Fabric weight/unit area (10 g/m ²)

^a – The values applied in averages (warp and weft)

Table 2b. Hand value of the natural colored silk

Treatments	Hand value of the natural colored silk [Smoothness]											
	No Dye	Mad der	RSW	Bar berry	Ann atto	Myro balan	Pomogr anate	On ion	Gra pe	M	SD	V
0	5.9	6.2	6.1	6.2	6.3	6.3	6.2	6.1	6.1	6.2	0.08	0.006
a	7.2	7.5	7.5	7.6	7.6	7.7	7.7	7.5	7.5	7.6	0.08	0.007
b	7.5	7.9	7.8	7.8	7.8	7.9	8.0	7.8	7.8	7.8	0.13	0.02
c	7.3	7.6	7.7	7.5	7.4	7.6	7.7	7.6	7.6	7.6	0.09	0.009
d	7.4	7.8	7.7	7.7	7.8	7.7	7.8	7.7	7.7	7.7	0.05	0.002
A	7.5	8.1	8.2	8.3	8.3	8.4	8.4	8.3	8.2	8.3	0.09	0.009
B	7.6	8.3	8.4	8.5	8.4	8.6	8.6	8.4	8.3	8.4	0.11	0.012
C	7.5	8.0	8.1	8.0	8.0	8.1	8.2	8.1	8.0	8.1	0.07	0.005
D	7.8	8.6	8.8	8.8	8.7	8.8	8.8	8.7	8.6	8.7	0.08	0.007
Treatments	Hand value of the natural colored silk [Stiffness]											
	No Dye	Mad der	RSW	Bar berry	Ann atto	Myro alan	Pomogr anate	On ion	Gra pe	M	SD	V
0	7.4	7.2	7.2	7.3	7.1	7.2	7.2	7.1	7.1	7.2	0.07	0.004
a	7.0	6.7	6.8	6.7	6.8	6.7	6.8	6.7	6.8	6.8	0.05	0.003
b	6.6	6.3	6.4	6.2	6.2	6.3	6.3	6.2	6.3	6.3	0.07	0.005
c	6.9	6.5	6.7	6.5	6.6	6.6	6.7	6.6	6.7	6.6	0.08	0.006
d	6.8	6.4	6.6	6.3	6.4	6.5	6.5	6.4	6.5	6.5	0.09	0.008
A	6.4	6.1	6.1	6.0	6.0	6.1	6.2	6.1	6.0	6.1	0.07	0.004
B	6.3	6.0	6.0	6.0	5.9	5.9	6.0	6.0	5.9	6.0	0.05	0.002
C	6.5	6.2	6.2	6.1	6.1	6.2	6.2	6.1	6.2	6.2	0.05	0.002
D	6.1	5.9	5.8	5.9	5.7	5.7	5.8	5.8	5.7	5.8	0.08	0.006
Treat	Hand value of the natural colored silk [Fullness]											

ments	No Dye	Madder	RSW	Barberry	Annatto	Myrobalan	Pomogranate	Onion	Grape	M	SD	V
0	6.5	6.7	6.7	6.8	6.7	6.7	6.8	6.7	6.8	6.7	0.05	0.002
a	7.3	7.6	7.5	7.8	7.7	7.6	7.7	7.5	7.7	7.6	0.09	0.009
b	7.9	8.2	8.1	8.2	8.3	8.2	8.3	8.3	8.0	8.2	0.10	0.01
c	7.5	7.8	7.7	7.9	7.8	7.8	7.9	7.7	7.8	7.8	0.07	0.005
d	7.7	8.0	7.9	8.1	8.0	8.0	8.1	8.0	7.9	8.0	0.07	0.005
A	8.1	8.4	8.4	8.5	8.6	8.5	8.6	8.5	8.5	8.5	0.07	0.005
B	8.2	8.5	8.5	8.6	8.7	8.7	8.8	8.7	8.7	8.7	0.10	0.01
C	8.0	8.3	8.3	8.4	8.4	8.3	8.4	8.4	8.3	8.4	0.05	0.003
D	8.4	8.7	8.6	8.8	8.8	8.9	8.9	8.8	8.8	8.8	0.09	0.009

3.3 Air-permeability and water-vapor-permeability of the natural colored silk fabrics

The values of air and water vapor permeability respectively of silk fabrics treated with selected finishing sources like aloe vera, amla, nocchi and recovered protein in the intact as well as in the combined form and colored using the natural sources such as madder, red sandal wood, barberry, annatto, myrobalan, pomogranate, onion, and grape are shown in Table 3. From the Table 3, it is observed that there is a uniform trend in the air permeability and water vapor permeability behaviors as revealed by the silk fabrics after different treatments and colorations. The air permeability is in accordance with the behavior of the water vapor permeability of the silk fabric. In connection with that the air permeability and water vapor permeability values are maximum for silk fabrics treated with finishing type of natural sources such as aloe vera, amla, nochi and recovered protein followed by colored with natural sources (D, B, A and C).

Table 3. Air-permeability and water-vapor-permeability of the natural colored silk

Treatments	Air-permeability of the natural colored silk (l/min)											
	No Dye	Madder	RSW	Barberry	Annatto	Myrobalan	Pomogranate	Onion	Grape	M	SD	V
0	72	78	78	79	81	80	79	80	80	79.38	0.99	0.98
a	75	85	86	86	88	86	86	88	87	86.5	1	1
b	93	105	105	106	105	106	107	106	105	105.6	0.69	0.48
c	82	93	94	93	94	93	94	95	94	93.8	0.66	0.44
d	87	98	99	99	99	98	100	100	99	99	0.71	0.5
A	98	113	114	114	115	113	115	116	115	114.4	0.99	0.98
B	102	118	118	119	120	118	119	120	120	119	0.87	0.75
C	95	109	109	110	110	109	111	111	110	109.9	0.78	0.61
D	106	126	125	124	125	125	124	126	125	125	0.71	0.5
Treatments	Water-vapor-permeability of the natural colored silk (g/m ² /day)											
	No Dye	Madder	RSW	Barberry	Annatto	Myrobalan	Pomogranate	Onion	Grape	M	SD	V
0	1578	1612	1618	1620	1620	1618	1620	1620	1619	1618.4	2.55	6.48

a	1655	1690	1696	1698	1698	1697	1695	1697	1698	1696.1	2.52	6.36
b	1685	1725	1727	1729	1730	1732	1728	1731	1730	1729	2.12	4.5
c	1667	1705	1708	1710	1712	1711	1708	1712	1710	1709.5	2.24	5
d	1675	1713	1716	1720	1719	1720	1717	1720	1719	1718	2.35	5.5
A	1697	1740	1739	1743	1742	1744	1742	1743	1742	1741.9	1.54	2.36
B	1704	1748	1747	1750	1751	1751	1750	1751	1750	1749.8	1.39	1.94
C	1690	1732	1732	1735	1735	1736	1734	1736	1736	1734.5	1.58	2.5
D	1714	1760	1760	1762	1762	1763	1762	1763	1762	1761.8	1.09	1.19

3.4 Uv-protection-factor-rating of the natural colored silk

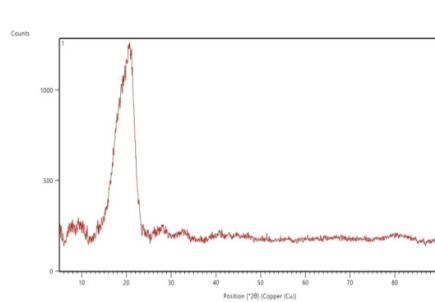
The uv protection factor rating of the dyed (madder, red sandal wood, barberry, annatto, myrobalan, pomegranate, onion, and grape) silk fabrics treated with protein, aloe vera, amla and nochi in different combinations was carried out by UV visible spectrophotometer and the data are given in Table 4. From the Table 4, it is seen that except the untreated one all the other natural colored and finished silk fabrics show very good to excellent uv protection factor values. In general, there is a maximum uv protection factor of the natural colored silk fabrics subjected with all the combinations (D) followed by the others (B, A, C, b, d, c, a and 0). Textiles are able to offer intrinsically uv protection as they have their inherent good protection against intense radiation from the sun if provided with the selective materials and constructions. UPF (uv protection factor) could be attributed far above for those of the sustained sunscreens (sun blocks). The intent for this method in the involvement of textiles for sun protection is verily highly demanded. Based on this concept, in order to assess the degree of protection to solar ultraviolet radiation of textile materials, in vitro test methods are probably used.

Table 4. Uv-protection-factor-rating of the natural colored silk

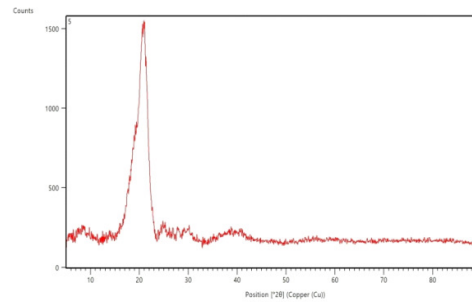
Treatments	Uv-protection-factor-rating of the natural colored silk										
	Madder	RSW	Barberry	Annatto	Myrobalan	Pomegranate	Onion	Grape	M	SD	V
0	22	20	21	20	22	21	22	20	21.00	0.87	0.75
a	26	25	26	25	26	26	27	25	25.75	0.66	0.44
b	38	39	38	37	39	38	39	38	38.25	0.66	0.44
c	32	33	34	33	35	34	36	35	34.00	1.23	1.50
d	34	34	35	34	36	35	37	36	35.13	1.05	1.11
A	42	41	41	40	40	41	41	40	40.75	0.66	0.44
B	42	42	42	43	42	43	42	41	42.13	0.60	0.36
C	40	40	39	38	39	39	40	39	39.25	0.66	0.44
D	43	43	42	44	44	43	44	43	43.25	0.66	0.44
Uv-protection-factor-rating for the textiles (Standard chart)											
Uv-protection-factor-rating				Category of protection				Uv radiation blocked (%)			
15-24				GOOD				93.3-95.9			
25-39				VERY GOOD				96-97.4			

3.5 X ray diffraction analysis of the natural colored silk

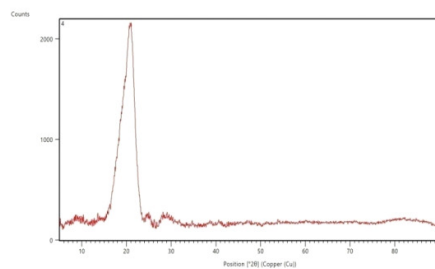
The X ray diffraction micrographs of the representative silk samples such as; the degummed silk fabric (1a), the silk fabric colored with red sandal (RSW) wood (1b), the protein (recovered sericin) treated and red sandal wood colored silk fabric (1c), the recovered sericin (with aloe vera) treated and red sandal wood colored silk fabric (1d), the recovered sericin (with aloe vera and nochi) treated and red sandal wood colored silk fabric (1e), and the recovered sericin (with aloe vera, amla and nochi) treated and red sandal wood colored silk fabric (1f) are given in Figure 1. The respective combined effect of X ray diffraction spectrogram of the natural colored silk is presented in the Figure 2. It is clear from the Figure 1, that there is a clear change in the sharpness of the peak in the XRD graphs. Also it is evident from the Figure 1 that the change is more obvious when the finishing source applications are increased on the silk fabrics. Subsequently, the silk fabrics applied with recovered sericin, aloe vera and nochi (1e) and recovered sericin, aloe vera, amla and nochi (1f) followed by coloring with red sandal wood indicate the change in a clear manner in the X ray diffractions micrographs.



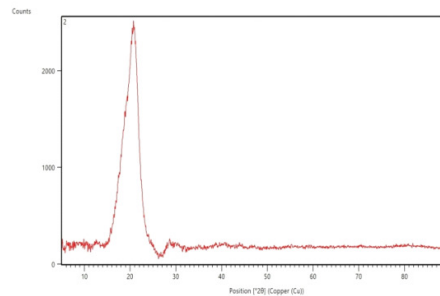
1a. Degummed silk fabric



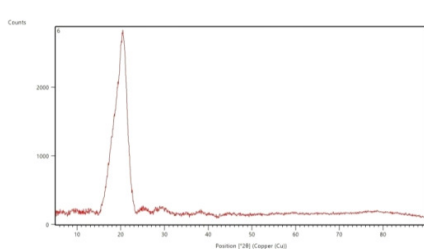
1b. Silk fabric colored with RSW



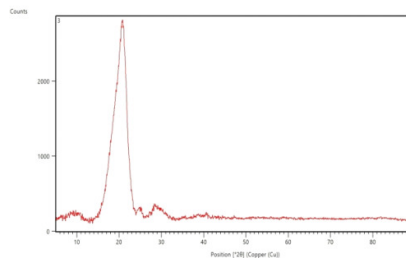
1c. Protein treated and RSW
and
colored silk fabric



1d. Protein (with aloe vera) treated
RSW colored silk fabric



1e. Protein (with aloe vera and nochi) treated and RSW colored silk fabric



1f. Protein (with aloe vera, amla and nochi) treated and RSW colored silk fabric

Fig 1. X ray diffraction spectrogram of the natural colored silk

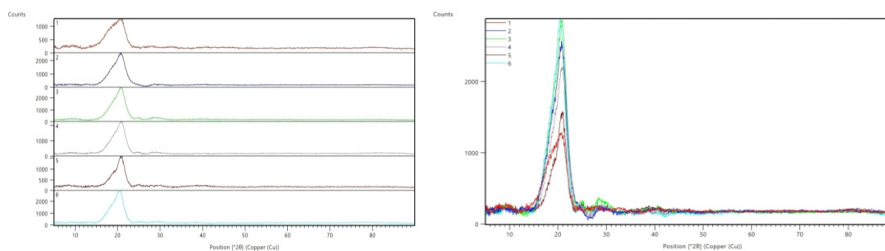
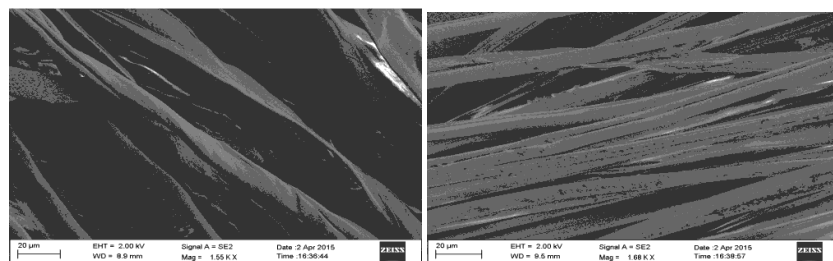


Fig 2. Combined effect of X ray diffraction spectrogram of the natural colored silk

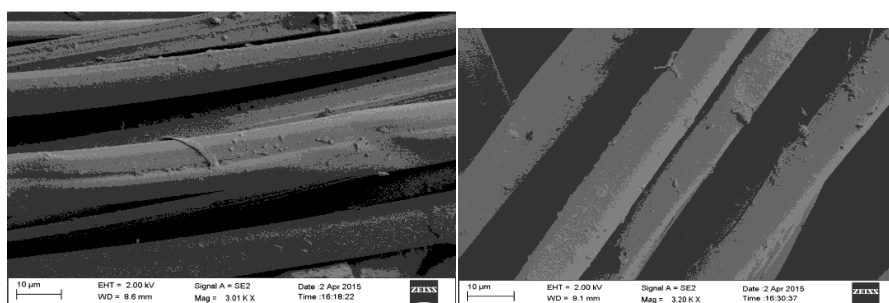
3.6 Scanning electron microscope analysis of the natural colored silk

The silk fabrics with the representative scanning electron microscope images are only shown in Figure 3. The degummed silk fabric (3a), the protein (recovered sericin) treated and red sandal wood (RSW) colored silk fabric (3b), the recovered sericin (with aloe vera and nochi) treated and red sandal wood colored silk fabric (3c), and the recovered sericin (with aloe vera, amla and nochi) treated and red sandal wood colored silk fabric (3d) are the respective samples given in the Figure 3. It is evident from these images that when the finishing source treatments (recovered sericin, aloe vera, nochi and amla) increased, the effect on the silk fabric also increases. The enhanced finishing effect is visible in the scanning electron microscope images in the case of the silk fabric treated with recovered sericin, aloe vera and nochi (3c); and recovered sericin, aloe vera, amla and nochi (3d) followed by coloring with red sandal wood.



3a. Degummed silk fabric

3b. Protein treated and RSW colored silk fabric



3c. Protein (with aloe vera and nochi) treated and RSW colored silk fabric

3d. Protein (with aloe vera, amla and nochi) treated and RSW colored silk fabric

Fig 3. Scanning electron microscope micrographs of the natural colored silk

4. CONCLUSIONS

The colorimetric data for the coloration are increased with the increase of treatment using the finishing type of natural sources such as aloe vera, amla, nochi and recovered sericin on silk fabrics and colored with natural sources. The increase of colorimetric data is maximum on the silk fabric treated with recovered sericin along with aloe vera, amla and nochi followed by colored with natural sources. The fastness property rating for the natural colored silk fabric subjected with the recovered sericin together with aloe vera, amla, and nochi in different combined form is in the good to very good trend. There is a moderate to good fastness property in the silk fabric applied using the recovered sericin with aloe vera, amla, and nochi and colored with natural sources.

There is a very good air-permeability in accordance with the behavior of the water-vapor-permeability in the silk fabric. Obviously, the air permeability and water vapor permeability values are higher for the silk fabrics subjected with finishing type of natural sources such as aloe vera, amla, nochi and recovered sericin followed by coloration with natural sources.

The surface hand value characters of the silk fabrics applied using the recovered sericin with the aloe vera, amla, and nochi and colored with the natural sources are in the good trend.

The x ray diffraction micrograms give the clear indication of the positive changes in the silk fabrics subjected with recovered sericin, aloe vera and nochi; and recovered sericin, aloe vera, amla and nochi followed by the coloration. The scanning electron microscope

images show the increased finishing effect in the case of the silk fabric subjected with recovered sericin, aloe vera and nochi; and recovered sericin, aloe vera, amla and nochi followed by the coloration.

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