Mulberry silk fabric treatment with natural colorants

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Abstract. Silk is the important versatile textile material being used for various delicate and formal enriched utilities. Traditionally for long period silk has been selected and colored with natural sources which would add values to the materials with respect to their original properties. Most of the natural sources have their inherent property add additional values to the silk materials. In this work the mulberry silk fabric is treated with recovered protein from sericin together with natural finishing sources like aloevera, amla and nochi in different combinations followed by coloring with few selected natural sources. The silk fabrics after these applications weresubjected for testing K/S value, fastness properties, absorbency, objective assessmentand SEM study. The results from these tests are impressive and positive suitable for the respective applications in the textile and garment utilities.

Keywords: Silk fabrics, natural sources, coloration, absorbency, sem.

1 Introduction

Theprotein based natural fibrous polymer, silkcontainsdifferent amino acids withfiber protein – fibroin (75%) and a gummy non-filamentous protein, Sericin (25%). The fiber protein-fibroin ($C_{15}H_{26}N_5O_6$) is the core for the fiber which is insoluble in hot water.The non-fibrous protein- sericin ($C_{15}H_{23}N_5O_6$) is a form of gum in the outer layer [1-3]. Silk is homogenous, hygroscopic, crystalline in nature, light in weight and the longest of all natural fibers [4-7]. Silk is superior towards comfort for high wearing, smooth feel to touch, lustrous to visibility, fine properties, required tensile strength, good appeal and aesthetic behaviorsrelevant for the quality, enriched fashioned garments and other end use products [8-11].

Silk is regarded as a symbol of royalty due to the lustrous appearance and peach-like softness.The specific gravity of silk filamentis of 1.250-1.300 g/cm^{3}with the cross section shaped of triangular [10-14]. Mulberry silk filament has no scales on the outer layers; contains the tenacity of 0.38N/Tex and elongation at break of 23.4% in the test condition of RH65% at 20^{o}C [15-20]. The degummed silk with translucence &smoothness is on the basis of the varied aspects of outward reflections on the surface, transmitted internal light, reflected internal light and light of diffusion [21-25].

As evidenced, the natural sources had been used elaborately for nearly 4000 years as colorants from plants with anti-insect properties involved for both herbal and coloring

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applications [26-28]. The developments in research activities towards natural colorgeneration and utilization is progressedwith respect to the widespreadimportance of natural lifestyle products based on eco-friendly sustainable process. Many plant origins were selected and used for the separation of extracts for coloring and the respective diversified application in the coloration and specific finishing of textile fiber substrates [29,30]. In this work raw silk fabric was selected and degummed for the removal of gum protein, sericin that was collected for the application along with the other natural sources like aloevera, amla, and nochi in different combinations followed by coloring with few listed eco-friendly sourcesnamely; madder, redsandal wood, barberry, annatto, myrobalan, pomogranate, onion, and grape. The results obtained from this work were convincing with respect to the suitability of utility in different textile and garment purposes.

2. Experimental

2.1 Materials

The raw silk fabric was purchased from the Sarvodhaya-Sangh, Coimbattore, Tamilnadu 641041. The fabric specifications of silk fabric are as: $2/80^{s}$for warp &weft count respectively, 100 - ends/inch,60 – picks/inch, 95 - GSM, and 44 inch - cloth width.The Tamil Nadu Forest Department, Coimbatore 641 043 (India) has supplied all the natural resources; i) madder, ii) red sandal wood, iii) barberry, iv) annatto, v) myrobalan, vi) pomogranate, vii) onion, and viii) grape are used for the coloration purposes; and ix) Aloevera, x) Amla, and Nochiare used for improved functional application purposes in addition to the protein (sericin) separated from raw silk fabric; separately and also in combined form on the silk fiber substrate with the coloring eco-friendly ingredients.AR grade is maintained for all the chemical items specified anywhere in this work.

2.2. Methods

2.2(i) Treatments on raw silk fabrics

The raw mulberry silk fabrics (plain, woven) were subjected by 10 gram per liter HClat ambient temperature for sixty min in a selected vessels of MLR (material-to-liquor ratio)1 ;30 to remove the size impurities. After this, the fabrics were degummed using sodium carbonate (2% on weight of material (owm)) and commercial degum soap powder (1% owm) at 85^{o}C for two hours. Finally, the degummed silk fabrics were washed thoroughly using de-ionized water and then dried [31-34].

2.2(ii)Collection of protein from the degummed bath

The remaining solution from the degummed bath is collected, separated and purified for the protein as per the established technique [35-39].

2.2(iii)Preparation of the extracts

The listed items for coloration namely madder, red sandal wood, barberry, annatto, myrobalan, pomogranate, onion, grape, aloevera, amla, and nochi are separated, purified and

the extractionis carried out in the aqueous method as explained by the established technique [40,41].

2.2(iv)Coloration and determination of k/svalues of dyed silk fabrics

The coloration was performed using the extracted eco-friendly itemson the silk fiber substrate already treated with the following natural sources in different aspects for the enhancement of dyed and finished effect;

o – without any treatment ;n1 – with recovered protein ; n2- aloevera with protein

n3- amla with protein n4- nochi with protein

nI - Protein with (aloevera and amla); nII - Protein with (Aloevera and Nochi) nIII- Protein with (Amla and Nochi); nIV - Protein with (Aloevera, Amla and Nochi)

The coloration process was carried out on the silk fabrics with the conditions, such as: concentration 25 gpl, temperature 95^{o}C, time 2 h, MLR 1:30based on the standard methods. The subsequentconcentration of [K / S] color was studied by Kubelka - MunkRelation which describes the connection of spectral reflectance(R) of sample and the respective absorption(K) and the scattering(S) characteristics; $K/S = ((1-R)^2/2R)$ [42-44].

2.2(v)Fastnessproperty measurement

The washing of eco-friendly colored silk fabrics were based on thetest method conditions of AATCC 135-1985, 2003 & AATCC 61-1996, 2003 to achieve the effect in the color change. Light fastness and staining fastnesstests were also carried out by AATCCconditions [45-47].

2.2(vi)Theabsorbency behavior

The absorbency characters of natural colored silk fabrics was measured as per the established AATCC - 79-2010; ASTM E96and ASTM D737 test methods [48-51].

2.2(vii)Objectiveassessment on natural colored silk fabricsby KES-F

The hand value characters of the natural colored silk fiber substrates were assessed by thetechnique of KES-F [52].

2.2(viii)SEMstudy on natural colored silk fabrics

The natural colored silk fabrics were analyzed for *SEM* study from 30-kV JEOL (Japan) Model, JSM-6360scanning electron microscope[53, 54].

3. Results and discussion

3.1. Natural coloration assessment study

3.1(i) Naturalcoloration and measurement of k/s values of the silk fabrics

The coloration process using the eco-friendly natural itemsis applied on silk fiber substrates which is treated already with selected finishing sources like aloevera, amla, nochi and recovered protein in the intact as well as in the combined form. The data obtained related to this type of application is presentedin the Table 1(i). From this, it is understood, the silk fabric gets good color in the range of red, orange red, yellow, orange, green, brown, red orange and purple when colored with the help of eco-friendly natural items. The data of k/s values are increased with the increase of treatment on silk fabrics using the finishing type of natural sources such as aloevera, amla, nochi and recovered protein. There is an increased data of k/s for the silk fabric treated by recovered protein with aloevera, amla and nochi followed by colored with natural sources (nIV, nII, nI and nIII). When the silk fabricis treated with recovered protein and one of the natural finishing sources (aloevera, amla, nochi) followed by coloration with natural coloring sources, k/s values are reduced in the normal manner (n2, n4, n3, n1). The k/s value is least for the silk fabric without any finishing natural source treatment, however only colored with the natural coloring sources (o).

Table 1(i). Natural coloration and measurement of k/s

S. No.	Natural sources (*Botanical name*)	Colors obtained	k/s of the natural colored silk fiber substrates								
			o	n1	n2	n3	n4	nI	nII	nIII	nIV
1	Madder (*Rubiacardifolia)*	Red	12.7	12.8	13.3	13.0	13.2	13.5	13.4	13.4	13.6
2	RS Wood (*Pterocarpussantallinus)*	Orange Red	12.6	12.9	13.4	13.1	13.3	13.6	13.7	13.5	13.8
3	Barberry (*Berberis vulgaris)*	Yellow	12.7	12.9	13.5	13.2	13.3	13.6	13.7	13.6	13.8
4	Annatto (*Bixaorellana)*	Orange	13.0	13.1	13.5	13.2	13.4	13.7	13.7	13.6	13.9
5	Myrobalan (*Terminaliachebula)*	Green	12.4	12.7	13.3	12.9	13.1	13.6	13.7	13.5	13.8
6	Pomogranate (Punicagranatum)	Brown	12.9	13.2	13.6	13.3	13.5	13.7	13.8	13.7	13.9
7	Onion (*Allium cepa)*	Red Orange	12.8	12.9	13.4	13.1	13.3	13.6	13.7	13.5	13.8
8	Grape (*Citrus paradise)*	Purple	12.5	12.7	13.4	12.9	13.1	13.5	13.7	13.4	13.8

RS Wood → Red sandal wood
o – without any treatment ;n1 – with recovered protein ; n2- aloevera with protein
n3- amla with protein n4- nochi with protein

nI - Protein with (aloevera and amla); nII - Protein with (Aloevera and Nochi) nIII- Protein with (Amla and Nochi); nIV - Protein with (Aloevera, Amla and Nochi)

3.1(ii)Fastnessproperty measurement of natural colored silk fabrics

The data of the fastness property (wash, light and stain) of the natural colored silk fabrics colored using the eco-friendly natural items treated already with selected finishing sources like aloevera, amla, nochi and recovered protein in the intact as well as in the combined form are presented in the Table 1(ii). From this, it is indicated that the fastness property of the natural colored silk fabric treated with the finishing natural sources in different combinations is good in general. There is a good to very good fatness property rating (3-4) for the natural colored silk fabric subjected with the recovered protein together with aloevera, amla, and nochi in different combined form. The fastness property is moderate to good (3) for the natural colored silk fabric treated already with the recovered protein with withaloevera, amla, and nochi separately. The natural colored silk fabric without any finishing sources treatment shows only poor to moderate (2-3) fastness property.

Table1(ii). Fastness property measurement of natural colored silk fabrics

S. No.	Dyes	Wash fastness					Light fastness					Stain fastness				
		o	n1	n2	n3	n4	o	n1	n2	n3	n4	o	n1	n2	n3	n4
1	Madder	2-3	3	3-4	3-4	3-4	3-4	3-4	4	4	4	2-3	2-3	3	3	3
2	RS wood	2-3	3	3	3	3	3	3-4	3-4	3-4	3-4	2	2-3	2-3	2-3	2-3
3	Barberry	3	3	3-4	3	3	3-4	4	4	4	4	2-3	2-3	3	2-3	3
4	Annatto	2-3	3	3-4	3	3-4	3-4	3-4	4	3-4	4	3	3	3	3	3
5	Myrobalan	3	3-4	3-4	3-4	3-4	3-4	4	4	4	4	3	3	3	3	3
6	Pomogranate	3	3-4	3-4	3-4	3-4	3-4	3-4	4	4	4	2-3	3	3	3	3
7	Onion	3	3	3	3	3	3	3-4	4	3-4	3-4	2-3	2-3	3	2-3	2-3
8	Grape	2-3	3	3	3	3	3	3-4	3-4	3-4	3-4	2	2-3	2-3	2-3	2-3

S. No.	Dyes	Wash fastness				Light fastness				Stain fastness			
		nI	nII	nIII	nIV	nI	nII	nIII	nIV	nI	nII	nIII	nIV
1	Madder	3-4	3-4	3	3-4	4	4	4	4-5	3	3	3	3-4
2	RS wood	3	3	3	3-4	3-4	4	3-4	4	2-3	3	2-3	3
3	Barberry	3	3-4	3	3-4	4	4	4	4	3	3	3	3-4
4	Annatto	3-4	3-4	3-4	4	4	4-5	4	4-5	3	3	3	3-4
5	Myrobalan	3-4	3-4	3-4	3-4	4	4	3-4	4-5	3	3-4	3	3-4
6	Pomogranate	3-4	3-4	3-4	4	4	4-5	4	4-5	3	3-4	3	3-4
7	Onion	3	3	3	3-4	4	4	3-4	4	3	3	2-3	3
8	Grape	3	3	3	3	3-4	3-4	3-4	4	2-3	2-3	2-3	3

3.2 Absorption study

The values of WR,WVP and APof silk fabric treated with selected finishing sources like aloevera, amla, nochi and recovered protein in the intact as well as in the combined form and colored using the eco-friendly natural items are presented in the table 2. As evidenced in this table 2, there is a direct relationship between the WR and WVP&APof natural colored silk fabric. The WVP and APbehavior is more on the treated and dyed silk fabric with respect to the relative increase of the WR. Accordingly, the increase of WR and WVP&AP are proceeded with the increase of treatment on silk fabrics using the finishing type of natural

sources such as aloevera, amla, nochi and recovered protein. The increase is maximum for the silk fabric treated by recovered protein with aloevera, amla and nochi followed by colored with natural sources (nIV, nII, nI and nIII). There is a marginal decrease in the WR andWVP&APbehaviors on the other treated and colored silk fabrics(n2, n4, n3, n1). These values are least for the colored silk fabrics without any finishing treatments (o).

Table 2. WR, WVP & AP of thenatural colored silk fabrics

S. No.	Dyes	Water retention, WR (%)								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	202	224	243	235	238	249	253	245	257
1	Madder	204	227	245	238	242	252	256	248	259
2	Red sandal wood	205	229	246	237	244	253	255	248	260
3	Barberry	204	229	245	238	243	251	255	247	259
4	Annatto	206	228	246	238	242	252	256	249	260
5	Myrobalan	205	228	245	237	242	252	255	248	261
6	Pomogranate	206	229	246	238	243	253	257	248	260
7	Onion	204	227	245	237	242	252	256	249	260
8	Grape	207	228	245	237	243	252	255	248	259
S. No.	Dyes	Water vapor permeability, WVP (g/m2/day)								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	1578	1655	1685	1667	1675	1697	1704	1690	1714
1	Madder	1612	1690	1725	1705	1713	1740	1748	1732	1760
2	Red sandal wood	1618	1696	1727	1708	1716	1739	1747	1732	1760
3	Barberry	1620	1698	1729	1710	1720	1743	1750	1735	1762
4	Annatto	1620	1698	1730	1712	1719	1742	1751	1735	1762
5	Myrobalan	1618	1697	1732	1711	1720	1744	1751	1736	1763
6	Pomogranate	1620	1695	1728	1708	1717	1742	1750	1734	1762
7	Onion	1620	1697	1731	1712	1720	1743	1751	1736	1763
8	Grape	1619	1698	1730	1710	1719	1742	1750	1736	1762
S. No.	Dyes	Air permeability, AP (l/min)								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	72	75	93	82	87	98	102	95	106

1	Madder	78	85	105	93	98	113	118	109	126
2	Red sandal wood	78	86	105	94	99	114	118	109	125
3	Barberry	79	86	106	93	99	114	119	110	124
4	Annatto	81	88	105	94	99	115	120	110	125
5	Myrobalan	80	86	106	93	98	113	118	109	125
6	Pomogranate	79	86	107	94	100	115	119	111	124
7	Onion	80	88	106	95	100	116	120	111	126
8	Grape	80	87	105	94	99	115	120	110	125

WR → Water retention; WVP→ Water vapor permeability; and AP → Air permeability

3.3. Objective assessment study byKES-F

The surface properties of natural colored silk fabrics are presented in Table 3(i), 3(ii) and 3(iii) based on the standard description as given in Table 3. From the Table 3(i) which gives the details regarding the smoothness, stiffness and fullness of the natural colored silk fabric. From this table it is shown that as 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. Similarly from the Tables 3(ii) and 3(iii) the bending length and crease recovery are decreased correspondingly with the increase of finishing source treatments using the recovered protein with other sources like aloevera, amla, and nochi in different combined forms followed by coloring with the natural sources.

Table3. Standard description for surface properties from KES-F

Description with unit
[a]Tensile
LT:Load/extension Linearity curve [None]
WT:Tensile energy [N/m]
RT:Tensile resilience [%]
[a]Bending
B:Bending rigidity [10^{-4}Nm]
HB:Hysteresis of bending moment [10^{-2}N]
[a]Shearing
G:Shear stiffness [N/m Deg.]
HG:Hysteresis of shear force at 0.5^{o} of shear angle [N/m]
HG5:Hysteresis of shear force at 5^{o} of shear angle [N/m]
Compression
LC:Linearity of compression/thickness curve [None]
WC:Compressional energy [N/m]

RC:Compressional resilience [%]
[a]**Surface**
MIU:Coefficient of friction [None]
MMD:Mean deviation of friction [None]
SMD: Geometrical roughness [µm]
Construction
T:Thickness of Fabric [Mm]
W:Weight/unit area of Fabric [10 g/m^2]

[a]→Average warp and weft direction values

Table3(i). Surface value of the natural colored silk fabrics

S. No.	Dyes	Surface value (Fullness) of the natural coloredsilk fabrics								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	6.5	7.3	7.9	7.5	7.7	8.1	8.2	8.0	8.4
1	Madder	6.7	7.6	8.2	7.8	8.0	8.4	8.5	8.3	8.7
2	Red sandal wood	6.7	7.5	8.1	7.7	7.9	8.4	8.5	8.3	8.6
3	Barberry	68	7.8	8.2	7.9	8.1	8.5	8.6	8.4	8.8
4	Annatto	6.7	7.7	8.3	7.8	8.0	8.6	8.7	8.4	8.8
5	Myrobalan	6.7	7.6	8.2	7.8	8.0	8.5	8.7	8.3	8.9
6	Pomogranate	6.8	7.7	8.3	7.9	8.1	8.6	8.8	8.4	8.9
7	Onion	6.7	7.5	8.3	7.7	8.0	8.5	8.7	8.4	8.8
8	Grape	6.8	7.7	8.0	7.8	7.9	8.5	8.7	8.3	8.8
S. No.	Dyes	Surface value (Stiffness) of the natural colored silk fabrics								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	7.4	7.0	6.6	6.9	6.8	6.4	6.3	6.5	6.1
1	Madder	7.2	6.7	6.3	6.5	6.4	6.1	6.0	6.2	5.9
2	Red sandal wood	7.2	6.8	6.4	6.7	6.6	6.1	6.0	6.2	5.8
3	Barberry	7.3	6.7	6.2	6.5	6.3	6.0	6.0	6.1	5.9
4	Annatto	7.1	6.8	6.2	6.6	6.4	6.0	5.9	6.1	5.7
5	Myrobalan	7.2	6.7	6.3	6.6	6.5	6.1	5.9	6.2	5.7
6	Pomogranate	7.2	6.8	6.3	6.7	6.5	6.2	6.0	6.2	5.8
7	Onion	7.1	6.7	6.2	6.6	6.4	6.1	6.0	6.1	5.8
8	Grape	7.1	6.8	6.3	6.7	6.5	6.0	5.9	6.2	5.7
S. No.	Dyes	Surface value(Smoothness) of the natural colored silk fabrics								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	5.9	7.2	7.5	7.3	7.4	7.5	7.6	7.5	7.8
1	Madder	6.2	7.5	7.9	7.6	7.8	8.1	8.3	8.0	8.6
2	Red sandal wood	6.1	7.5	7.8	7.7	7.7	8.2	8.4	8.1	8.8
3	Barberry	6.2	7.6	7.8	7.5	7.7	8.3	8.5	8.0	8.8
4	Annatto	6.3	7.6	7.8	7.4	7.8	8.3	8.4	8.0	8.7
5	Myrobalan	6.3	7.7	7.9	7.6	7.7	8.4	8.6	8.1	8.8

6	Pomogranate	6.2	7.7	8.0	7.7	7.8	8.4	8.6	8.2	8.8
7	Onion	6.1	7.5	7.8	7.6	7.7	8.3	8.4	8.1	8.7
8	Grape	6.1	7.5	7.8	7.6	7.7	8.2	8.3	8.0	8.6

Table3(ii). BL values of the natural colored silk fabrics

S. No.	Dyes	BL (mm) of the natural colored silk fabrics [Warp (Cw)]								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	10.4	10.0	9.7	09.9	09.8	09.5	09.4	09.6	09.3
1	Madder	10.2	09.8	09.3	09.6	09.5	09.0	08.8	09.2	08.5
2	Red sandal wood	10.1	09.7	09.3	09.6	09.5	09.1	08.9	09.2	08.3
3	Barberry	10.3	09.8	09.4	09.7	09.5	09.1	08.9	09.3	08.6
4	Annatto	10.2	09.8	09.3	09.6	09.4	09.1	09.0	09.2	08.8
5	Myrobalan	10.1	09.8	09.3	09.6	09.5	09.0	08.8	09.2	08.6
6	Pomogranate	10.3	09.7	09.3	09.5	09.4	09.1	08.9	09.2	08.6
7	Onion	10.3	09.8	09.4	09.6	09.5	09.2	09.0	09.3	08.7
8	Grape	10.2	09.7	09.4	09.6	09.5	09.1	08.9	09.3	08.7
S. No.	Dyes	BL (mm) of the natural colored silk fabrics [Weft (Cf)]								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	10.2	09.7	09.4	09.6	09.5	09.2	09.2	09.3	09.1
1	Madder	09.9	09.4	08.8	09.2	09.0	08.7	08.5	08.9	08.4
2	Red sandal wood	10.0	09.3	08.9	09.2	09.1	08.7	08.6	08.8	08.4
3	Barberry	09.9	09.4	08.8	09.2	09.0	08.8	08.5	08.9	08.3
4	Annatto	09.8	09.3	08.9	09.1	09.0	08.7	08.6	08.8	08.4
5	Myrobalan	09.9	09.4	08.8	09.2	09.1	08.7	08.5	08.9	08.3
6	Pomogranate	10.0	09.4	08.8	09.1	09.0	08.8	08.6	08.9	08.4
7	Onion	09.9	09.3	08.9	09.2	09.1	08.7	08.5	08.8	08.5
8	Grape	09.9	09.4	08.9	09.2	09.1	08.7	08.6	08.8	08.4

BL → Bending Length

Table3(iii). CR values of the natural colored silk fabrics

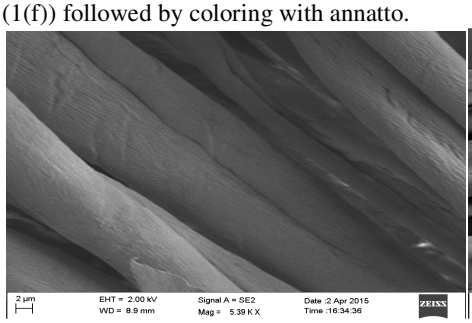
S. No.	Dyes	CR (^{o}) of the natural colored silk fabrics [Warp (Cw)]								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	117	114	110	113	112	108	107	109	106
1	Madder	113	111	106	109	108	105	104	106	103
2	Red sandal wood	115	111	107	110	109	104	103	106	103
3	Barberry	114	110	105	109	107	103	103	104	102
4	Annatto	114	111	107	110	109	104	104	106	103
5	Myrobalan	115	112	108	111	110	105	104	107	103
6	Pomogranate	113	111	107	110	109	105	104	105	102
7	Onion	115	112	106	111	108	104	103	106	102

8	Grape	114	112	107	110	109	105	104	106	103
S. No.	Dyes	CR (^{o}) of the natural colored silk fabrics [Weft (Cf)]								
		o	n1	n2	n3	n4	nI	nII	nIII	nIV
0	No Dye	113	112	109	111	110	107	106	108	104
1	Madder	111	109	104	108	106	102	100	103	98
2	Red sandal wood	109	108	104	107	105	102	101	103	99
3	Barberry	110	109	103	106	105	101	100	102	98
4	Annatto	110	108	104	107	106	102	101	103	98
5	Myrobalan	109	108	103	106	105	101	100	102	99
6	Pomogranate	110	109	104	107	106	102	100	103	98
7	Onion	111	108	103	106	105	101	100	102	99
8	Grape	109	108	103	106	105	102	101	103	98

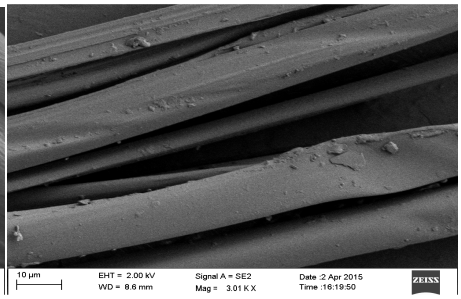
CR → Crease recovery

3.4. Surface morphology study bySEM

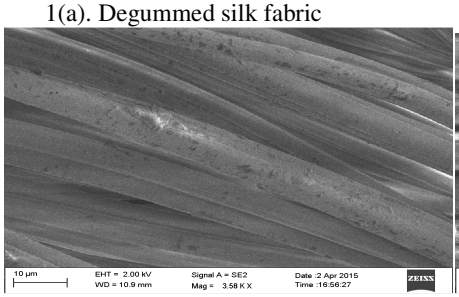
The SEM images of representative silk fabrics are only shown in Figure 1. The degummed silk fabric (1(a)), the annatto colored silk fabric (1(b)), the recovered protein treated and annatto colored silk fabric (1(c)), the recovered protein (with aloevera) treated and annatto colored silk fabric (1(d)), the recovered protein (with aloevera and nochi) treated and annatto colored silk fabric (1(e)), and the recovered protein (with aloevera, amla and nochi) treated and annatto colored silk fabric (1(f)) are the respective samples given in Figure 1. From these figures it is clear that as the finishing source treatments (recovered protein, aloevera, nochi and amla) increases the effect on the silk fabric also increases. The increased finishing effect is seen in the SEM images in the case of the silk fabric subjected with recovered protein , aloevera and nochi (1(e)); and recovered protein, aloevera, amla and nochi (1(f)) followed by coloring with annatto.

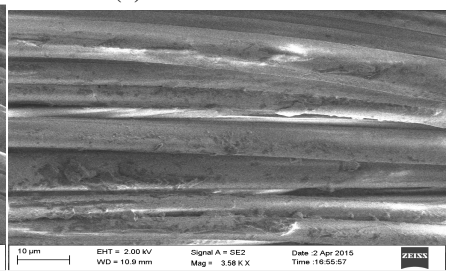


1(a). Degummed silk fabric



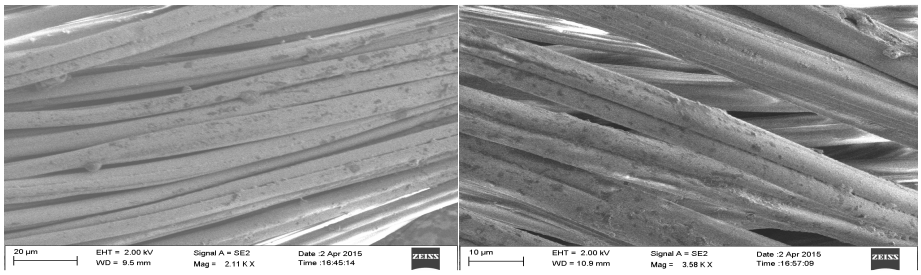
1(b). Annatto colored silk fabric





1(c). Recovered protein treated and annatto coloredsilk fabric

1(d). Recovered protein (with aloevera) treated and annatto colored silk fabric



1(e). Recovered protein (with aloevera and amla nochi)treated and annatto colored silkfabricsilk fabric

1(f). Recovered protein (with aloevera, and nochi) treated and annatto colored

Figure 1. SEM images of silk fabrics

4. Conclusion

The k/s values are increased with the increase of treatment using the finishing type of natural sources such as aloevera, amla, nochi and recovered protein on silk fabrics and colored with natural sources . The increase of k/s value is maximum for the silk fabric treated by recovered protein with aloevera, amla and nochi followed by colored with natural sources.There is a good to very good fatness property rating for the natural colored silk fabric subjected with the recovered protein together with aloevera, amla, and nochi in different combined form. The fastness property is moderate to good for the silk fabric treated with the recovered protein with aloevera, amla, and nochi separately and colored with natural sources.

The increase of water retention, water vapor and air permeability are proceeded with the increase of treatment on silk fabrics using the finishing type of natural sources such as aloevera, amla, nochi and recovered protein. The air permeability is in accordance with the behavior of the water vapor permeability of the silk fabric. By the way, the water vapor permeability and air permeability value are maximum for silk fabrics treated with finishing type of natural sources such as aloevera, amla, nochi and recovered protein followed by colored with natural sources.

The mechanical and surface properties of silk fabrics treated with the recovered protein with aloevera, amla, and nochi and colored with natural sources are in the suitable uniform trend. The increased finishing effect is seen in the SEM images in the case of the silk fabric subjected with recovered protein, aloevera and nochi; and recovered protein, aloevera, amla and nochi followed by coloring.

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