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Review Article

Dyeing and Antibacterial Finish of Soybean Fabric Using Marigold

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Abstract

The Soybean Protein Fibre (SPF) has good empathy to human skin. The natural colour of Soybean fibre is light yellow, and it mostly resembles the colour of silk. With good fastness to light and moisture, it also has more dyeing brilliance and dyeing fastness than silk. The Soybean Protein Fibre (SPF) is regenerated protein fibre with various applications in textiles because of its unique properties. Though, due to the lack of antibacterial properties of such protein comprising polymers, it is detained as drawback for its applications on hygienic textiles. Hence it is essential to make it antibacterial. On the other side, a lot of marigold flowers which is antibacterial by nature, is used in Idol worship causes a huge rate of temple waste. There is incredible prospective to make use of those wastes as a good source of natural dye that is eco-friendly. A study says that the tannin mordant was obtained from the seed coats of tamarind, amla and harda and their application in natural dyeing by means of temple waste marigold as a dye was carried out. Marigold dyeing by using most available alum mordant was also carried out for association of the purpose. After dyeing the SPF fabrics with these mordants, it was evaluated for antibacterial activities, colour brilliance, fastness properties as well as durability of the same. The results clearly suggested the advantages of using such mordants are beneficial in case of achieving antibacterial functionality as well as eco-friendly dyeing.

Keywords: SPF; Temple waste marigold; Natural dyeing; Eco-friendly; Natural mordant; Antibacterial properties

ISSN: 2578-0271

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Submission: January 04, 2022

Published: February 11, 2022

Volume 6 - Issue 4

How to cite this article: Subrata Das, Josephine D. Dyeing and Antibacterial Finish of Soybean Fabric Using Marigold. Trends Textile Eng Fashion Technol. 6(4). TTEFT. 000641. 2022. DOI: 10.31031/TTEFT.2022.06.000641

Introduction

Textiles that are especially made from natural fibres are commendable medium for the growth of microorganisms because; they provide all basic requirements such as moisture, nutrients, oxygen and appropriate temperature. The large surface area and ability to retain moisture of textile materials also assist the growth of microorganisms on the fabric [1] and therefore it results in pertaining unsolicited effects on both textile material as well as the wearer. These effects include the generation of foul smell, stains, reduction in tensile strength, decolourization in fabric and an increased likelihood of contamination [2]. In past few decades, there was an increase in new antimicrobial fibre technologies due to the growing awareness about cleaner environment and healthy hygiene lifestyle. It initiated to develop a range of textile products based on synthetic antimicrobial agents such as triclosan, metal and their salts, phenols, organometallics and quaternary ammonium compounds and few of them are available commercially [3]. In spite of such excellent antimicrobial availability, their effect on environment is always a question. Due to this backdrop, some of the natural dyes reported to possess antimicrobial properties drawn attention of the researchers in this field. Besides this, the development of synthetic dyes taking place at the beginning of the twentieth century has come a long way and led to a more complete level of quality [4]. Due to wide applications of synthetic dyestuffs on variety of fibres and fabrics, it causes many environmental pollutions and harmful effects because of their toxic degraded products and non-biodegradable nature. Some serious health hazards like allergenicity and carcinogenicity are caused due to the usage of synthetic dyes. And due to this, some of synthetic dyes were banned. Hence it is essential to revive world heritage and traditional wisdom of using safer natural dyes. As most of the consumers always relay on sustainability, the natural dyes are gaining more importance as they are obtained from renewable resources, eco-friendly and free from health hazards and some of them act as incredible health care products too [5].

However, natural dyes with few expectations are non-substantive and hence it must be used in combination with mordants. Mordant is a chemical, which can fix itself on the fibre and also combines with the dyestuff. Tannin is an astringent vegetable product available in a wide variety of plant parts that includes bark, leaves, wood, fruit pods, fruit, roots and plant galls. Tannins are naturally occurring water soluble polyphenolic compounds with high molecular weight of about 500-3000 a d it contains phenolic hydroxyl groups that enable them to form effective crosslinks between the proteins and other macromolecules [6]. They are predominantly used in the preservation of leather, glues, stains and mordants. Application of tannin based natural mordants in natural dyeing was reported in earlier twenties [7].

The species of Mexican marigold named Tagetes erecta has significant antibacterial effect against many airborne disease-causing grams negative and gram-positive bacteria and predominantly against bacteria that cause skin infection [8]. There is most common practice in India of throwing the temple flowers once used in Idol worship into river, which leads to water pollution [9]. The waste disposal of such flowers in rivers is an issue and hence discovering the potential of using this flower waste from temples for dyeing of textile has been undertaken [10]. Dyeing of textiles with marigold flower as a dye as such has been reported earlier [11]. Tannins in such marigold flowers are astringent and antimicrobial in nature. Hence the application of natural dyes using these natural mordants can serve for dual purpose as natural coloration and antibacterial finishing for textile materials [12]. Even though tannin containing plants are available in adequately, the usage of such sources for extracting mordants to be used in natural dyeing has been found to a very limited extent. Currently, the simultaneous dyeing and antibacterial finishing of Soybean Protein Fibre (SPF) was carried out by natural mordants extracted from harda (myrobalan), amla and Tamarind Seed Coat (TSC). The colour values were assessed and compared with those attained using alum mordant. The antibacterial efficiency of the dyed textile material and the durability of the antibacterial activity on the textile material were considered.

Objective

The main objective is to make use of potential values of the huge temple waste marigold flowers. The tannin content present in the marigold flower serves as natural mordant that can serve for dual purpose as natural coloration and antibacterial finishing for textile materials.

Materials

Soybean protein fibre yarn of 30 counts was knitted to make single jersey fabric which was hot washed, bleached and prepared for dyeing. All chemicals used were of laboratory grade. Waste marigold flowers are obtained from ISCON temple, Mumbai [13].

Methods

a. Extraction of mordant

By dissolving 10gm of mordant powder in 1000ml water, the 1% stock solution of alum was prepared. The 1% stock solution was prepared by boiling 10gm of mordant powder in 1000ml water for 1 hour in case of natural mordants. The extract was thoroughly filtered and made to 1000ml which was supposed for mordanting the prepared soybean protein fabric.

b. Extraction of dye

The 1% stock solution of the marigold dye was prepared by boiling 10 grams of well dry marigold flower in 1000ml of water for 1 hour. The extract was filtered thoroughly and completed to 1000ml, and this is subjected for dyeing the SPF fabric.

c. Mordanting and dyeing of SPF

The mordanting of Soybean protein fabric was processed in rota dyer machine by maintaining the liquor to material ratio as 30:1. The fabrics were immersed into the mordant solution at room temperature initially and gradually the temperature was increased to 95 0C. The mordanting was sustained at this particular temperature for about 30 minutes [14]. After the mordanting process, the subsequent fabric was squeezed well and dyed by means of marigold flowers extract that is obtained from dry marigold flowers as the dye. The mordanted fabrics were immersed into dyebath and dyeing was sustained at 90 0C for the time of 1hour. After this dyeing process, the fabrics were taken out, squeezed and washed thoroughly with the cold water.

d. Colour value by reflectance method

The resultant dyed samples were assessed for the colour depth by the reflectance method by means of 100 spectators. The absorbance property of the samples was dignified on Spectra flash SF 300 (Data colour International, U.S.A.) fortified with reflectance fixtures. The colour strength K/S values were determined by the expression.

$K/S = (1-R)2 /2R$

Here, 'R' is the reflectance at whole opacity,

'K' is the absorption coefficient and

'S' is the Scattering coefficient.

Dyed fabric samples were simultaneously evaluated in terms of CIEL*A*B* colour space values using the Spectra flash SF300. Generally, the higher the value of K/S denotes the higher depth of colour on the fabric. L* denotes the brightness (100= white, 0= black), a* denotes the red-green coordinate (positive indicates red colour, negative indicates green colour) and b* denotes the yellow-blue coordinate (positive indicates yellow colour, negative indicates blue colour). Finally, a grouping of all these colours helps one to understand the different shade variations of a colour.

e. Washing fastness

Estimation of colour fastness towards washing was processed using ISO II methods [15]. Washing liquor used here was a

solution that comprises 5 grams per litre of soap solution. The dyed samples were treated for 45 minutes at 50 0C expending liquor to material ratio of 50:1 in the rota machine. After rinsing and drying the samples, the change in colour and staining on the undyed fabric samples. They were evaluated based on the respective standard scales that includes rating from 1 to 5, where 1 - poor, 2 - fair, 3 - good, 4 - very good and 5 - excellent).

f. Rubbing fastness

Estimation of colour fastness towards rubbing that includes dry and wet conditions was processed using "crock-meter" with 10 repetitions of rubbing.

g. Light fastness

Dyed fabric was verified for colour fastness towards light based on ISO 105/B02 (ISO technical manual, 2006). The light fastness was assessed by means of artificial illumination with Xenon, which is a light source, Q-Sun Xenon Testing Chamber with black standard temperature of 65 0C, the relative humidity of the air in the testing chamber should be 40% and daylight filter, wavelength, k= 420nm. The samples were equated with the standard scale of blue wool reading that includes ratings from 1 to 8, where 1-poor, 2- fair, 3-moderate, 4-good, 5-better, 6-very good, 7-best and 8-excellent.

h. Determination of antibacterial activities of dyed fabrics

The antibacterial activity of the dyed fabrics was measured by AATCC Test Method 100-2004 [16]. The lessening in number of bacterial colonies formed with respect to the not treated fabric samples was calculated by using succeeding equation, R =100 (B - A)/ B where, R is the percentage reduction in bacterial count; A is the number of bacterial colonies improved from the inoculated preserved test specimen samples in the jar incubated for 24 hours contact period; B is the number of bacterial colonies improved from the inoculated untreated control test specimen samples in the jar instantaneously after inoculation that is at "0" contact time.

i. Durability of antibacterial activity

The durability of the samples to laundering was evaluated using washing conditions as per ISO 105-CO6-1M.

Results and Discussions

A. Optimization of dye and mordant concentrations

The dyeing of the SPF fabric engaging most normally castoff alum metal mordant and some of natural mordants such as harda, seed coat of Tamarind Seed Coat (TSC) and amla was tried and consequent results are abridged in the following tables. The first attempt of the study was to identify the contribution of dye and mordants towards the colour standards of the dyed SPF fabrics. Therefore, SPF fabrics were primarily in one instance, it was just mordanted and not dyed and in second instance, it was dyed without pre-mordanting. The consequences in Table 1 showed the raise in colour strength K/S values with high concentration of the mordants. It should be well-known that SPF fabrics that are subjected for dyeing were originally slightly yellowish in colour and henceforth showing different colour values without using any mordants or dyes. Alum mordant showed least result on colour values with collective concentration from 5-20%. Yet the tannin mordants exhibited marked rise in K/S with increasing mordant concentration. Amid the tannin mordants, tannin mordant of amla exhibited the highest rise in K/S and it is followed by harda mordants and Tamarind Seed Coat (TSC). Generally, the raise in concentration of tannin mordants resulted in raise in redness of the shades. The results of marigold dye concentration towards colour brilliance were also examined and results are summarized in Table 2.

Table 1: Effect of mordant concentration on colour values of mordanted SPF.

Mordant	Mordant Conc. (%)	K/S	L*	a*	b*
Alum	5	1.2446	74.291	1.439	22.537
	10	1.3994	73.128	0.754	20.975
	15	1.4118	74.694	1.544	23.659
	20	1.4693	73.469	4.095	23.251
Harda	5	2.9399	60.723	2.096	16.725
	10	10 2.9865	63.185	2.542	19.774
	15	3.7779	62.779	2.533	19.132
	20	3.8037	63.743	2.941	20.289
TSC	5	1.8239	62.611	5.474	20.257
	10	1.9895	62.747	6.305	20.272
	15	2.2879	60.853	6.411	18.329
	20	2.3663	60.151	7.269	17.606

Amla	5	2.8717	58.163	3.883	17.081
	10	3.1386	59.4	3.923	18.503
	15	3.8041	58.903	4.216	18.3
	20	4.2542	58.595	4.175	17.752

Table 2: Effect of dye concentration on colour values of dyed SPF samples.

Dye	Dye Conc. (%)	K/S	L*	a*	b*
	5	2.8686	66.085	1.844	22.632
Marigold	10	3.7455	65.77	1.433	21.748
	15	4.0097	62.028	3.439	23.052
	20	4.2397	60.888	3.566	22.208

The K/S values displayed raises with raising dye concentration from 5%-20%. The SPF fabric exhibited good dye capability to marigold dye in absence of mordants that might be because of the presence of amino groups in protein fibres like SPF fabric which reports the functionally towards the dye molecules. The increase in dye concentration also resulted in increase in redness of the colour shades. The results of dyeing of marigold using different mordants are abridged in Tables 3-6. The values of K/S were seemed to be enhanced with increasing alum concentration upto 20%; but the relative increase in K/S values from mordant concentration from 15% to 20% was comparatively lower. Henceforth 15% mordant concentration was taken as an optimum concentration. By keeping the alum concentration constant, K/S values were seemed to be raised with marigold dye concentration from 5%-20%. The colour values so obtained in the instance of natural dyes are a combined contribution of the consequence of mordant and the dye. Hence the colour strength was improved with mordant and dye concentration firstly till the equilibrium condition was reached. The rise in concentrations of either dye or mordant beyond optimum concentrations did not pointedly contribute to the improvement of the depth of dyeing and that is revealed in K/S values.

Table 3: Effect of varying concentration of Alum and marigold on colour values of dyed SPF fabric.

Alum (%)	Marigold (%)	K/S	L*	a*	b*
	5	5.5228	66.503	4.355	40.756
5	10	10.0529	66.442	2.726	38.444
	15	11.8729	67.955	2.494	40.142
	20	13.4266	60.742	4.682	43.456
	5	6.4807	54.323	7.55	39.602
10	10	10.2255	57.923	6.135	43.042
	15	10.9399	60.551	5.577	43.867
	20	14.2789	68.874	2.044	39.643
	5	6.9268	66.975	4.445	40.6
15	10	10.577	58.389	4.69	40.499
	15	14.641	61.319	4.491	43.981
	20	17.8174	58.786	4.622	43.592
	5	7.3248	53.109	3.367	33.784
20	10	12.2046	57.255	5.261	41.354
	15	13.2829	58.661	5.324	43.309
	20	17.9598	58.955	4.931	43.635

Table 4: Effect of varying concentration of Harda and marigold on colour values of dyed SPF fabric.

Harda (%)	Marigold (%)	K/S	L*	a*	b*
	5	3.8059	59.989	3.815	22.823
5	10	3.9802	60.794	3.348	22.195
	15	4.6245	66.897	1.721	22.338
	20	5.2931	68.401	1.277	22.828
	5	4.1157	58.313	2.647	18.26
10	10	5.4387	58.423	3.833	24.827
	15	5.5844	56.737	3.789	23.531
	20	6.1405	57.532	3.771	23.359
	5	5.0177	56.43	4.14	23.707
15	10	5.7317	65.096	3.067	24.264
	15	5.7487	56.074	3.747	23.257
	20	6.5905	59.177	3.575	24.976
	5	5.1231	54.98	4.213	22.963
20	10	5.6716	58.058	4.134	24.591
	15	5.8756	59.135	3.528	24.259
	20	7.5429	64.339	2.523	23.862

Table 5: Effect of varying concentration of Tamarind seed coat and marigold on colour values of dyed SPF fabric.

TSC (%)	Marigold (%)	K/S	L*	a*	b*
	5	3.1716	57.521	5.263	19.836
5	10	3.3931	56.043	6.303	18.757
	15	3.7691	59.234	4.967	20.474
	20	5.2415	52.322	3.279	13.519
	5	3.5341	55.684	6.42	18.19
10	10	3.7573	57.479	6.211	19.698
	15	3.9831	55.447	7.731	19.901
	20	5.2722	57.642	6.808	20.923
	5	3.6433	53.455	7.366	18.365
15	10	3.879	55.522	7.19	19.941
	15	4.7567	60.272	5.984	21.011
	20	5.3063	53.636	7.732	21.596
	5	5.2149	59.647	7.065	22.212
20	10	5.2149	55.183	7.825	22.603
	15	5.3063	58.16	7.06	21.309
	20	6.0307	62.653	5.363	22.324

Table 6: Effect of varying concentration of Amla and marigold on colour values of dyed SPF fabric.

Amla (%)	Marigold (%)	K/S	L*	a*	b*
	5	2.9932	59.741	3.697	18.686
5	10	4.0619	59.83	3.858	18.714

	15	4.5883	64.118	3.319	21.258
	20	4.7118	62.274	3.176	20.012
	5	4.0555	61.247	3.666	19.474
10	10	4.2796	61.026	3.315	19.092
	15	5.5623	54.517	4.456	21.355
	20	5.9055	53.447	4.116	20.306
	5	4.2504	50.999	5.307	19.553
15	10	4.5406	53.81	4.309	20.984
	15	5.6058	51.26	4.162	18.839
	20	6.3601	53.206	4.362	20.44
	5	4.5298	50.599	4.829	19.08
20	10	5.9158	52.435	4.814	20.199
	15	6.401	54.839	4.348	21.749
	20	6.5611	53.625	4.554	21.15

Values in Table 4 obviously indicate that there is raise in K/S values with increasing harda concentrations from 5% - 20% and that was alike in case of all the natural mordants. However, the colour values got almost increased for 15% of mordant concentration and that was also the instance when SPF fabrics were mordanted (Table 1). For a constant mordant concentration, K/S values raised with increasing dye concentration. The higher K/S values attained for the pre-mordanted, and dyed fabric as compared to that of the fabric sample which was not mordanted before dyeing evidently showed the role of natural tannins acting as a mordant in natural dyeing. Though these natural mordants displayed good colour values for marigold dyeing, they were found to be lower than those obtained using alum as a mordant. The tonal variations in colour shades of dyed SPF fabrics, as specified by a* and b* values, were seemed to be different with mordant and dye combinations (Tables 3-6); however, the shades variations were obtained using various mordant and dye combinations assisting one to have huge choice of hues from the scope of different shades obtained in the instance of natural dyeing. The results in Table 7 obviously specify the fastness properties of the dyeing obtained by means of various mordants. By these we come to know that the mordants play a vital role in holding the dye on the fabric. Form Table 7, it is obvious that the washing fastness found varied in the range of very good to excellent grade. The rubbing fastness was also seemed to be of the grade good to excellent and the light fastness seemed to be quite acceptable [17].

Table 7: Effect of mordant type (20%) and marigold (20%) on fastness properties.

Mordant	Mordant	Marigold	Fastness Properties		
	Conc. (%)	Conc. (%)	Washing	Rubbing	Light
	-	20	2	03-Apr	2
Alum	15	20	04-May	04-May	5
	20	20	04-Apr	04-May	5
Harda	15	20	4	4	5
	20	20	4	04-May	5
TSC	15	20	04-May	04-May	5
	20	20	4	04-May	5
Amla	15	20	4	04-May	5
	20	20	4	04-May	5

B. Antibacterial activity of marigold dyed SPF fabric

The measurable antibacterial valuation was made using AATCC-100(2004) test method and the consequences are shown in Table 8 & Table 9. The results of antibacterial activities of SPF fabric samples only mordanted and the samples only dyed as well as that of samples both mordanted and dyed are shown in Table 8. The only dyed fabric sample shows the least extent of antibacterial activity amongst the three classes of the samples. The antibacterial

property is higher in the samples in only mordanted than that of the samples only dyed. However, mordanted and dyed samples exposed the highest antibacterial property. All those three natural mordants resulted similar degree of overall antibacterial activity on dyeing with marigold [18-21].

Table 8: Effect of mordant type (20%) and marigold (20%) on antibacterial properties.

Mordant	Mordant	Marigold	Bacterial Reduction (%)	
	Conc. (%)	Conc. (%)	*s.aureus*	*E.coli*
	20	-	62.25	60.8
Alum	-	20	45.05	44.75
	20	20	90.3	86.75
Harda	20	-	63.98	62.58
	20	20	90.2	87.25
TSC	20	-	62.2	61.75
	20	20	89.75	87.1
Amla	20	-	60.8	60.1
	20	20	88.65	86.25

Results in Table 9 shows that the washing durability of such antibacterial property, irrespective of the mordant used, was up to 20 cycles of wash which is based on the conjecture that minimum 70% decrease in bacterial count is a tolerable limit. And the other thing that is to be noted is, among the three natural mordants tried, washing durability of the antibacterial property was better in instance of Amla and TSC, as compared to Harda which is commonly used in natural dyeing as a source of tannin, and this was identified when dyed samples were compared after 20 washes.

Table 9: Durability of antibacterial properties on marigold dyed SPF fabric.

Mordant	Mordant	Marigold	Number of Washes	Bacterial Reduction	
	Conc. (%)	Conc. (%)		*s.aureus*	*E.coli*
			0	90.3	86.8
			5	84.2	83.2
Alum	20	20	10	81.1	80.3
			20	73.3	71.5
			30	65.3	64.9
			0	90.2	87.25
			5	81.2	81.2
Harda	20	20	10	75.3	73.75
			20	69.75	68.25
			30	62.5	61.6
			0	89.75	87.1
			5	86	84.1
TSC	20	20	10	79.25	78.4
			20	74.25	73.05
			30	65.55	64.8
			0	88.65	86.25
			5	83.15	81.5
Amla	20	20	10	78.4	76.15

			20	73.7	71.3
			30	64.3	62.55

Conclusion

Antibacterial finishing and Eco-friendly dyeing of SPF fabric was effectively carried out using natural mordants (alum, harda, TSC, amla) and marigold dye extract. The dyed sample exhibited good colour strength (K/S), although it was lesser than that in those attained using metal mordant like alum. However, the fastness properties were comparable for both natural and metal types of mordants. The natural mordanted-dyed fabric samples displayed broad spectrum and long-lasting antibacterial activity. The huge marigold flower wastes from temples thus can be efficiently used not only for dyeing of SPF fabric, but also to impregnate antibacterial property which resist the growth of harmful microorganisms into it. It also gives hygiene appeal to the wearer that is highly needed for all human beings. The replacement of metal mordant by the natural mordents like seed coat of tamarind and Amla which discretely contributes towards antibacterial property, moreover it showed improved level in such property upon dyeing with marigold dye. This concept of natural dyeing of SPF fabric by means of natural mordant with an aim to create a wide range of shades and meanwhile the impartment of antibacterial property performs to be indeed promising one.

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