J. Cotton Res. Dev. **37**(2), 276-285 (July, 2023) **ISSN No. 0972-8619**

Effect of Banyan leaves extract finish on properties of cotton fabric

RAJNI, SAROJ YADAV*, AND NEELAM M. ROSE
Department of Textile and Apparel Designing, CCS Haryana Agriculture University, Hisar- 125004
**Email : *saroj16.yadav@gmail.com*

Abstract : The increasing concern of consumers towards health and environment has shifted the focus of textile industries towards the use of natural sources to replace the lethal effect of synthetic chemicals. Herbal finishes are eco friendly in nature and have beneficial effects on human health. Considering the issues of green consumerism and hazardous effects of synthetic finishes the present investigation was carried out for the development of bacterial resistant finish for cotton fabric with banyan leaves extract and study the effect of finish on antimicrobial, physical and functional properties of treated cotton fabric. The banyan leaves extract was applied on scoured cotton fabric through exhaust and pad dry cure techniques. Effect of herbal finish on properties of finished cotton fabric was tested. After treatment with banyan leaves extract the cotton fabric exhibited 94.62 and 93.54 per cent reduction in the bacterial count of *Staphylococcus aureus* and *Escherichia coli*. After 5 washing cycles, the treated fabrics exhibited 71.68 and 69.09 per cent reduction in the bacterial count of *S. aureus* and *E. coli* respectively whereas after 10 washing cycles, the reduction in bacterial count was 68.14 and 63.27 percent for *S. aureus* and *E. coli*, respectively. The banyan leaves extract treated fabrics were tested for change in physical properties and it was found that fabric weight, thickness, bending length, flexural rigidity, crease recovery angle and elongation of plant extract treated fabric were increased whereas fabric count, tensile strength, moisture regain and air permeability were decreased. The herbal treated fabrics exhibited excellent ultraviolet protection *i.e.* 41.93. Conclusively, banyan leaves were observed as an efficient natural source for imparting bacterial resistant finish on cotton fabric.

Keywords: Banyan leaves extract, cotton fabric, herbal finish, properties

India is the second largest producer of fibre in the world and the major fibre produced is cotton. This fibre possess unique properties, such as good moisture absorbency, light weight, soft hand, durability, biodegradability, comfortable to wear and easy to colour. According to the lifestyle and retail monitor survey, more than 9 in 10 consumers state that they would like to choose cotton over synthetic active wear if cotton could wick moisture, regulate temperature, be light weight, hold or lock colour and resist UV rays (Cotton Incorporated Lifestyle Monitor, 2018). Although being the most favourite choice for summer, cotton lacks in two major protection categories, it is the poorest UV absorber, as compared to polyester (best UV absorber), wool, silk and nylon and it offers an ideal environment for the adherence, transfer and propagation of infection causing microbes when remain in contact with the human body. Cotton fabrics are susceptible to bacterial attack because they retain oxygen, water and nutrients (Crews *et al.*, 1999).

Microbial action is a dominant factor limiting the service life performance of textiles. The detrimental effects of microbes can be seen on the wearer and on the fabric itself in terms of contamination risk, odour formation, microbial attack, loss of the performance properties of textile substrate, strength reduction, quality loss, *etc.* It is becoming increasingly important to maintain hygiene through the effective use of textile materials. Hence, to protect the wearer from infection and improve the performance properties of the textile substrate, development of antimicrobial textile finish is highly

indispensable and relevant since garments are in direct contact with human body (Gopalakrishnan and Aswini, 2013).

Antimicrobial property can be imparted to the textile material through a number of synthetic chemical bases including inorganic salts, organometalics, iodophores, phenols and thiophenols, antibiotics, hetrocyclics with anionic groups, nitro compounds, urea, formaldehyde derivatives and amines (Ristic *et.al.*, 2019). Though the synthetic antimicrobial agents are very effective against a wide range of microbes and give a durable effect on textiles, but these are associated with some side effects like action on non target micro organism and due to their synthetic nature they also create environmental problems. As the people are more aware about the environmental loads and side-effects of synthetic chemicals, use of natural products in textile finishing is gaining significant momentum (Lee *et. al.*, 2009; Hussain and Jahan, 2019 and Thilagavathi and Kannaian, 2010).

The use of crude extracts from different parts of diverse species of plants like roots, leaves, stems, flowers and seeds, and the bioactive compounds present in plants like saponins, tannins, flavonoids, phenols, etc. have a great significance for the development of antimicrobial finish for textiles due to fungicidal and bactericidal properties.

Although certain natural antibacterial agents are presently in use but only few studies have reported their antibacterial activity on textiles. These natural sources are complex mixtures of several compounds and also the composition varies in different species of the same plant. However, due to non-toxic and eco-friendly nature, these sources are still considered as novel and safe means for the development of medical and health care textiles.

Recently, there has been upsurge interest in apparel technology all over the world for much demanding functionality of the products like wrinkle resistance, water repellence, fire resistance and resistance to microbial invasion. With the increase in new antimicrobial textile finishes and the growing awareness about cleaner surroundings and healthy lifestyle there is a need to develop the process for imparting natural antimicrobial agents to the textile substrate, where the properties of the resultant treated textiles are unaltered.

Considering the relatively lower incidence of adverse reactions of herbal products as compared to modern synthetic pharmaceuticals, coupled with their reduced cost, the present investigation was carried out to obtain the natural antimicrobial extract for development of microbial resistance finish for cotton and to study its effect on physical and functional properties of treated fabric.

1. **Preparation of cotton fabric:** The plain weave cotton fabric with 60x58 ends and picks/inch, weighing 149.80g/m2 having relative thickness of 0.298 mm was used for the experimental work. To ensure uniform wetting, enzymatic desizing and scouring of selected cotton fabric was done as per protocol of Jose *et al.*, 2016.
2. **Preparation of herbal extract:** Aqueous extract of shade dried banyan leaves was prepared by triple percolation method i.e. the filtrate was obtained after 24+12+12 hours of merceration, keeping the MLR

Table 1: Efficacy of treated fabrics to bacterial resistance

Treated fabrics	Bacterial count (CFU/ml)	
	Staphylococcus aureus	*Escherichia* coli
Untreated (control)	40.0×10^7	44.03×10^7
Exhaust method	2.15×10^7	2.84×10^7
Pad- dry -cure method	1.67×10^7	1.89×10^7

1:10 at 50°C temperature.

3. **Application of herbal extract on fabric:** Exhaust and pad dry cure methods were used for finishing of cotton fabric with herbal extract, citric acid was used as a cross linking agent.

i. **Exhaust method**: The scoured fabric was immersed in antibacterial solution of 17 per cent concentration of banyan leaves extract using 1:30 material to liquor ratio (MLR) and 8 per cent (owf) cross linking agent for one hour maintaining temperature of 60° C with occasional stirring. The herbal treated fabric was shade dried.

ii. **Pad dry cure method:** The fabric was immersed in the antimicrobial solution consisting of 17 per cent banyan leaves extract, 6 per cent (owf) cross linking agent with MLR 1:20 for 10 minutes maintaining temperature of 60° C with occasional stirring. The extract impregnated fabric was passed between the rollers of the pneumatic padding mangle at a speed of 3m/min. at pneumatic pressure of 1 kg/cm2. The finished fabric was shade dried and cured at 140°C for 3 minutes.

4. **Assessment of antimicrobial activity of herbal extract:** Both control (untreated) and herbal treated fabric samples were evaluated for their bacterial resistance property against two common human bacteria *i.e. S. aureus* and *E. coli* using AATCC Test Method 100. The colonies of bacteria were counted manually and total colony forming units were calculated using following formula:
Colony Forming Units (CFU) = No. of colonies x Dilution factor x Inoculum of bacterial culture (ml)= Counts/ml

5. **Assessment of durability of finish to washing:** Durability of herbal finish to washing was evaluated using 'Launder-o-Meter' as per IS: 3361-1979 test method. The herbal treated samples were subjected to 5, 10 and 15 wash cycles.

6. **Physical, functional and performance properties of banyan leaves extract treated fabrics:** The physical, performance and functional properties of control and banyan leaves extract treated fabric were tested using the following standard test methods.

Properties	**Test Method**
i. Preliminary properties	
Fabric count	ASTM–D123
Fabric weight	ASTM D3776-90
Fabric thickness	BS 2544: 1967
ii. Mechanical properties	IS: 6490-1971
Bending length and flexural rigidity	
Tensile Strength and elongation	IS: 4169
iii. Performance properties	
Crease recovery angle	BS 3086:1972
Moisture regain	BS1051:1960
Air permeability	ASTM-D737
iv. Functional property	
Ultraviolet Protection Factor	UVR TRANSMISSION AATCC-183:2004.

Bacterial resistance of treated fabrics: The results related to the bacterial resistance efficacy of the herbal treated fabrics in terms of bacterial count to both the test bacteria are incorporated in Table 1.

It is apparent from the Table that the bacterial count of untreated (control) fabric was 40.0x107 and 44.03x107 for *Staphylococcus aureus* and *Escherichia coli*, respectively. When banyan leaves extract was applied on the fabric by exhaust method, the bacterial count observed for *Staphylococcus aureus* and *Escherichia coli* was 2.15 x107 and 2.84 x 107, respectively. The cotton fabric when treated with banyan leaves extract using pad dry cure method, the bacterial

count noted for *Staphylococcus aureus* was 1.67 x107 and for *Escherichia coli* was 1.89 x107.

It is thus concluded that the banyan leaves extract treated fabric had the lower bacterial count as compared to untreated (control) fabric. It is further observed that pad-dry-cure method of extract application provided the higher bacterial resistance to the treated cotton fabric against *Staphylococcus aureus* and *Escherichia coli* bacteria in comparison to exhaust method of application.

Per cent reduction in bacterial growth of treated fabrics: The per cent reduction in the bacterial count on the banyan leaves extract treated fabric was calculated from the bacterial count of the untreated (control) fabric. The bacterial count on both the treated fabrics was compared with the untreated (control) fabric and results were computed as per cent reduction in the bacterial count.

The data in Table 2 narrates that when banyan leaves extract was applied on the cotton fabric by exhaust method, the per cent reduction in growth of *Staphylococcus aureus* and *Escherichia coli* bacteria was observed as 94.62 and 93.54 per cent, respectively as compared to untreated fabric. In case of application of extract by pad dry cure method, 95.82 per cent reduction in growth of *Staphylococcus aureus* and 95.70 per cent reduction in growth of *Escherichia coli* were observed in comparison to untreated (control) fabric.

Thus, it is inferred that per cent reduction in growth of both the test bacteria was found to be increased to a great extent when banyan leaves extract treatment was imparted to cotton fabric by both the application methods. It was also noticed that when the banyan leaves extract was applied on cotton fabric by pad dry cure method somewhat higher percent reduction in the growth of *Staphylococcus aureus* as well as *Escherichia coli* bacteria was observed as compared to exhaust method.

Retention of bacterial resistance property of treated fabrics after washing: Effect of washing on retention of banyan leaves extract treatment was studied to find out the changes in bacterial resistance property of treated fabric after washing. The bacterial count on the washed fabrics was compared with their respective treated unwashed fabrics and the reduction in the bacterial count was computed as percent reduction in the bacterial count.

It is discerned from the Table 3 that the fabrics treated with banyan leaves extract by exhaust method showed decrease in percent reduction in growth of *Staphylococcus aureus* from 71.68 to 68.14 per cent and from 69.09 to 63.27 percent in growth of *Escherichia coli* after 5 and 10 washes respectively. When the treatment

Table 2: Per cent reduction in bacterial count of treated fabrics

Treated fabrics	Per cent reduction in bacterial count	
	Staphylococcus aureus	*Escherichia coli*
Exhaust method	94.62	93.54
Pad dry cure method	95.82	95.70

Table 3: Retention of bacterial resistance treatment on treated fabrics after washing

Treated fabrics	Washing cycles	Per cent reduction in bacterial count	
		Staphylococcus aureus	*Escherichia coli*
Exhaust method	0 (Control)	94.62	93.54
	5	71.68	69.09
	10	68.14	63.27
Pad dry cure method	0 (Control)	95.82	95.70
	5	73.47	70.98
	10	62.61	59.72

Table 4: Effect of bacterial resistant treatment on preliminary properties of cotton fabric

Treated samples	Properties							
	Fabric count (ends and picks/ inch)				Fabric weight (g/m^2)		Fabric thickness (mm)	
	Warp Mean ± S.E (m)	Weft Mean ± S.E (m)	Mean (warp + weft)	Percent change	Mean ± S.E. (m)	Percent change	Mean ± S.E (m)	Percent Change
Scoured (Control)	60.00±0.70	58±0.70	59	-	149.80±0.73	-	0.29±0.005	-
Exhaust method	45.80±1.15	48.80±0.58	47.3	-19.83	153.80±0.37	+2.67	0.33±0.005	+13.79
t-value	17.75**	8.26**	-	-	4.47*	-	3.91*	-
Pad dry cure method	52±0.50	48.80±0.58	50.4	-14.57	156.40±0.50	+4.40	0.37±0.051	+27.58
t-value	10.91**	8.26**	-	-	6.12**	-	14.90**	-

**1% level of significance; * 5 % level of significance; + indicates increase in property; - indicates decrease in property; S.E. =Standard error

was applied with pad dry cure method decrease in the growth of *Staphylococcus aureus* from 73.47 to 62.61per cent was observed and for *Escherichia coli* decrease in growth from 70.98 to 59.72 per cent was noticed with increase in washing cycles from 5 to 10.

It is thus obvious from the Table that the antibacterial efficacy of banyan leaves extract treated fabrics decreased with the increase in washing cycles but herbal treated fabrics retained their bacterial resistance property with more than 50 per cent reduction in bacterial growth of both the test bacteria even after 10 washing cycles. The findings of the study are in line with the results of Fadhel *et al.*, (2012) and Puspa (2014) who reported percentage bacterial reduction of fabric finished with herbal extracts reduced gradually with the increase in washing cycles. Muhsina and Thamaraiselvi (2017) found that treated fabric sustained 80 per cent of antibacterial activity against the test bacteria until 8 wash cycles and after that a slight reduction in the activity of fabric was noticed.

Effect of bacterial resistant treatment on preliminary properties of fabrics: The data regarding the effect of banyan leaves extract treatment on preliminary properties *i.e.* fabric count, weight and thickness are presented in Table 4. The data in the Table depict that the fabric count of scoured (control) cotton fabric was 60 ends and 58 picks/inch, weighing 149.80 g/m2 having thickness 0.298 mm. Fabric count decreased by 19.83 per cent in fabric treated by exhaust method and 14.57 per cent in sample treated by pad dry cure method. It was revealed that the cotton samples treated with banyan leaves extract by exhaust method showed more decrease (19.80%) in fabric count. There was significant difference between the samples treated by both the finish application methods. Gupta (2016) reported a decrease in fabric count of woven fabric and stitch density of knitted fabric finished with *S. cumini* (L.) leaves extract in the presence and absence of resin cross linking agent. Similar, findings were also reported by Kumari (2019) and Yadav (2019) that fabric count of herbal treated fabric decreased as compared to untreated fabric.

It is evident from the Table that the weight and thickness of the fabric increased after herbal treatment. The fabrics treated by exhaust method showed increase in weight from 149.80 to 153.80 g/m2 and thickness from 0.298 to 0.336 mm whereas with pad dry cure method the increase in weight from 149.80 to 156.40 g/m2 and thickness from 0.298 to 0.374mm was noticed. The weight and thickness of fabric treated by exhaust method increased by 2.67 and 13.79 per cent, respectively.

Similarly, fabric treated by pad dry cure method showed 4.40 and 27.58 per cent increase in weight and thickness, respectively. Thus it is concluded that when the extract was applied by pad dry cure method the per cent increase in terms of weight/unit area (4.40%) and thickness (27.58%) was higher. Poonia (2018) and Sushila

Table 5: Effect of bacterial resistant treatment on mechanical properties of cotton fabric

Treated samples	Properties													
	Bending length (cm)				Flexural rigidity (mg-cm)		Tensile strength (kg)				Elongation (%)			
	Warp Mean ± S.E. (m)	Weft Mean ± S.E. (m)	**Mean (Warp +Weft)**	Percent change	**Mean ± S.E. (m)**	Per cent change	Warp Mean ± S.E. (m)	Weft Mean ± S.E. (m)	**Mean (warp + weft)**	Per cent change	Warp Mean ± S.E. (m)	Weft Mean ± S.E (m)	**Mean (warp + weft)**	Per cent change
Scoured (Control)	4.10 ± 0.07	3.68 ± 0.08	**3.89**	-	**2.18 ± 0.08**	-	8.70 ± 0.07	7.50 ± 0.07	**8.1**	-	13.38 ± 0.06	13 ± 0.07	**13.19**	-
Exhaust method	4.74 ± 0.05	4.48 ± 0.04	**4.61**	+18.50	**2.56 ± 0.05**	+17.43	7.34 ± 0.05	7.20 ± 0.10	**7.27**	-10.24	14.30 ± 0.07	13.90 ± 0.07	**14.1**	+6.89
t-value	5.94**	11.31**	**-**	-	**2.96***	-	14.66**	2.12	**-**	-	9.48**	28.46**	**-**	-
Pad dry cure method	4.98 ± 0.08	4.54 ± 0.06	**4.76**	+22.36	**2.92 ± 0.05**	+33.94	7.28 ± 0.05	6.98 ± 0.86	**7.13**	-11.97	15.14 ± 0.10	14.66 ± 0.05	**14.9**	+12.96
t-value	7.90**	8.77**	**-**	-	**14.51****	-	17.75**	4.49*	**-**	-	12.26**	16.12**	**-**	-

**1% level of significance; * 5 % level of significance; + indicates increase in property; - indicates decrease in property; S.E. = Standard error

(2018) mentioned that weight of fabric increased when the herbal extract was applied by exhaust and pad dry cure methods.

Effect of bacterial resistant treatment on mechanical properties of fabrics: It is learnt from the Table 5 that an increase in bending length and flexural rigidity of scoured fabric was noticed from 4.10 to 4.74 cm and from 2.18 to 2.56 mg-cm respectively after treatment with banyan leaves extract through exhaust method. When plant extract was applied through pad dry cure method, the bending length and flexural rigidity of scoured cotton fabric increased from 4.10 to 4.98 cm and from 2.18 to 2.92 mg-cm, respectively. The per cent increase in bending length and flexural rigidity was found higher in the sample treated by pad dry cure method as compared to sample treated with exhaust method. Statistically, at 1 per cent level of significance, significant difference was found in bending length among the means of both types of treated fabrics in warp and weft directions.

The data in Table illustrates that the mean tensile strength of the scoured fabric was 8.10 kg (8.70 kg for warp and 7.50 kg for weft direction) which decreased from 8.1 to 7.27 (10.24%) when banyan leaves extract treatment was imparted on cotton fabric by exhaust method. The tensile strength of samples treated with banyan leaves extract by pad dry cure technique decreased from 8.10 to 7.17 kg (11.97%).

The data in Table narrates that elongation of scoured cotton fabric increased from 13.19 to 14.1 per cent when banyan leaves extract was applied by exhaust method. While, elongation of scoured cotton fabric increased from 13.19 to 14.90 per cent when the extract was applied through pad dry cure method. Statistically the significant difference was found in the means of elongation for warp direction as well as in means of weft direction of samples treated by both the application methods. The percent increase in elongation was higher for the fabric treated by pad dry cure method (12.96%) than the fabric treated by exhaust method

Table 6: Effect of bacterial resistant treatment on performance properties of cotton fabrics

Treated Samples	Properties							
	Crease recovery angle (degree)		Moisture regain (%)				Air permeability ($m^3/m^2/min$)	
	Warp Mean ± S.E (m)	Weft Mean ± S.E (m)	Mean ± S.E (m)	Per cent change	Mean ± S.E (m)	Per cent change	Mean ± S.E (m)	Per cent change
Scoured (Control)	42.80±0.58	37.60±0.74	40.2	-	4.18±0.05	-	177±0.44	
Exhaust method	47.60±0.81	40±0.70	43.8	+8.95	3.78±0.05	-9.56	167.20 ± 0.80	-5.53
t-value	5.58**	3.53*	-	-		5.65**	-	8.46**
Pad dry cure method	50.20±0.66	46.40±0.50	48.3	+20.14	3.74±0.09	-10.52	162±0.70	-8.47
t-value	6.34**	9.07**	-	-	3.41*	-	23.71**	

**1% level of significance; * 5 % level of significance; + indicates increase in property; - indicates decrease in property; S.E. = Standard error

Table 7: Effect of bacterial resistant treatment on ultraviolet protection property of cotton fabric

Untreated (Control)	8.07	8.98	11.76	No protection
Exhaust method	2.97	2.56	41.93	Excellent
Pad dry cure method	2.53	2.44	48.06	Excellent

UPF Rating:-15, 20: Good protection; 25,30,35: Very good protection; 40,45,50,50+:Excellent protection

(6.89%) as compared to scoured fabric. Sood (2014) found increase in bending length and flexural rigidity of antibacterial finished fabrics as compare to untreated fabrics. Similarly, Shafei *et al.*, (2018) observed that the tensile strength decreased with cross linking of extract during treatment. Yadav (2019) found that elongation of herbal treated fabric increased when extract was applied by exhaust and pad dry cure methods.

Effect of bacterial resistant treatment on performance properties of cotton fabric: The data regarding effect of bacterial resistant herbal treatment on performance properties of cotton fabric in terms of crease recovery, moisture regain and air permeability are presented in Table 6.

The data in Table demonstrates that the crease recovery angle of untreated fabric was 42.80 and after treatment of fabric with banyan leaves extract using exhaust method, the crease recovery angle was observed as 47.600 which indicated 8.95 per cent increase in treated fabric as compared to scoured fabric. When the treatment was given by pad dry cure method, the crease recovery angle was observed as 50.200 with an increase in recovery angle (20.14%) as compared to scoured fabric. The results are in consonance with Verma (2017) and Yadav (2019) who found increase in crease recovery angle of treated fabrics.

The data in Table exhibits that the moisture regain of untreated fabric was 4.18 per cent and after treatment of fabric with plant extract by exhaust method, it was observed as 3.78 per cent which depicted decrease of 9.56 per cent in moisture regain of herbal treated fabric. When treatment of scoured fabric with herbal extract was performed by pad dry cure method, the moisture regain was noticed as 3.74 per cent which showed decrease of 10.52 per cent as compared to the control fabric. The per cent decrease was found more (10.52%) for fabric treated by pad dry cure method in comparison to fabric treated by exhaust method (9.56%).

The data in Table reflects that the air permeability of untreated fabric was 177 m3/m2/min and after treatment of fabric with plant extract by exhaust method, it was observed as 167.20 m3/m2/min which depicted decrease of 5.53 percent. When scoured fabric was treated with banyan leaves extract by pad dry cure method, the air permeability was noticed as162 m3/m2/min which indicated decrease of 8.47 percent. The decrease in air permeability of fabric finished by exhaust and pad dry cure methods was found to be significant at 1 per cent level of significance. The per cent decrease was found slightly higher (8.47%) for fabric treated by pad-dry cure method in comparison to fabric treated by exhaust method (5.53%). Similar results were noticed by Nagpal (2017) that moisture regain in fabric sample finished with plant extracts and their combinations decreased significantly as compared to their controlled samples. The results are in consonance with Singh (2017) that decrease in moisture regain of finished samples may be due to more surface deposition of organic molecules of the extract on the surface of the fabric

Effect of bacterial resistant treatment on functional properties of plant extract treated cotton fabrics: Functional properties in terms of ultraviolet protection factor of the control and treated fabrics were determined to measure the ultraviolet protection property.

The data in Table 7. exemplifies that the UPF value of control sample was 11.76 depicting that the untreated fabric did not have any protection factor. The scoured cotton fabric when treated with banyan leaves extract by exhaust and pad-dry-cure method, the UPF value increased to 41.93 and 48.06, respectively, demonstrated excellent protection. It is deduced from the table that the banyan leaves extract treated fabrics exhibited higher UPF value as compared to untreated cotton fabric. The fabric treated by pad dry cure method provided more ultraviolet protection than fabric treated by

exhaust method. Furthermore, it was inferred that banyan leaves extract played a significant role in enhancing UPF value of both the treated samples which achieved the excellent protection category. Shafei *et al.*, (2018) also found that fabric treated with green tea extract in presence of cross-linking agent showed improved UPF value when compared with other natural plant chamomile and sage. Green tea dyed fabric exhibited increased UV protection property of cotton fabric.

CONCLUSION

The herbal extract of banyan leaves was found to possess very high antibacterial properties against *Staphylococcus aureus* and *Escherichia coli*. Thus it is recommended as a natural eco friendly, safe antibacterial agent. The treatment of cotton fabric with banyan leaves herbal extract enhanced the fabric weight, thickness, bending length, flexural rigidity, elongation, crease recovery angle and UPF value. Hence it will help in manufacturing of antibacterial, ultraviolet protective and easy care textiles required for medical, sports and field activities.

REFERENCES

Cotton Incorporated Lifestyle Monitor. 2018. Top performances. Lifestyle cotton incorporated monitor. Retrieved from http://lifestylemonitor.cottoninc.com/tag/activewear on October 3, 2018.

Crews PC, Kachman S and Beyer A.G. 1999. Influences on UVR transmission of undyed woven fabrics. *Tex. Chem. Colo.* **31**:17-21.

Fadhel, B.B., Aissi, A., Ladhari, N., Deghrigue, M., Chemli, R. and Joly, J.P. 2012. Antibacterial effects of two *Tunisian Eucalyptus* leaf extracts on wool and cotton fabrics. *J. The Textile Ins.*, **103** :1197-1204.

Gopalakrishnan, M and Aswini, D. 2013. Antimicrobial activity of Coleus ambonicus herbal finish on cotton fabric. Fib. *Textiles in East. Eur.*, **4** :106-09.

Gupta V., 2016. UV protection and antibacterial finish on cotton using plant extracts. *Ph.D. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Hussain, A. and Jahan, S. 2019. Textiles protection against ultraviolet radiation. *The Indian Textile J.* Retrieved from www.indiantextilejournal.com/ articles FAdetails on july 6, 2019

Jose, S, Salim, R and Ammayappan, L. 2016. An overview on production, properties, and value addition of pineapple leaf fibers (PALF). *J. Nat. Fib.*, **13** : 362-73.

Kumari, M. 2019. Antibacterial finish on cotton using Giloy extract. *M.Sc. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Lee, Y.H., Hwang, E.H. and Kim, H.D. 2009. Colorimetric assay and antimicrobial activity of cotton, silk and fabrics dyed with peony, clove, Coptis chinensis and gallnut. *Materials*, **2**:10- 21.

Muhsina, C.P. and Thamaraiselvi B. 2017. Antimicrobial finish for cotton fabric from Mirabilis jalapa leaf extract. *J. Enviro. Sci., Toxicol. Food Technol.*, **11**:13-17.

Nagpal, A. 2017. Application of weed plants extracts on cotton and silk for microbial resistance. *Ph.D. Thesis*, CCS Haryana

Agricultural University, Hisar, Haryana.

Poonia, N. 2018. Efficacy of kinnow peels extract for microbial resistance on cotton fabric. *M.Sc. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Puspa, 2014. Utilization of karanja extracts on cotton fabric for microbial resistance. *Ph.D. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Singh, N. 2017. Microbial resistance of cotton and silk finished with plant extracts. *Ph.D. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Shafei, A EI, Shaarawy, S, Motawe and Refaei, R. 2018. Herbal extracts as an ecofriendly antimicrobial finishing of cotton fabric. *Egyptian J. Chem.* **61** :317-27.

Sood A., 2014. Application of herbal extracts on covering fabric of sanitary napkins for bacterial resistance. *Ph. D. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Sushila, 2018. Efficacy of lemon peels extract for microbial resistance on cotton fabric. *M.Sc. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Thilagavathi, G. and Kannaian, T. 2010. Combined antimicrobial and aroma finishing treatment for cotton using microencapsulated geranium (*Pelargonium graveolens* L.) leaves extract. *Indian J, Nat, Prod, Res,*, **1**: 348- 52.

Verma, M. 2017. Effect of biopolymer treatment on dyeing efficiency of cotton fabric. *Ph.D. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Ristić, T, Zemljič, L.F., Novak, M., Kunčič, M.K., Sonjak, S., Cimerman, N.G. and Strnad S. 2019. Antimicrobial efficiency of functionalized cellulose fibres as potential medical textiles. Science against Microbial Pathogens: Communicating Current Research and Technological Advances. Retrived from www.formatex.info/microbiology3/book/36-51.pdf on August 11, 2019.

Yadav, S. 2019. Antibacterial finish for cotton fabric using herbal extract. *M. Sc. Thesis*, CCS Haryana Agricultural University, Hisar, Haryana.

Received for publication : March 25, 2023
Accepted for publication : April 22, 2023