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Cotton fabric functionalized with banyan leaves extract for developing antimicrobial textiles

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Abstract : The comprehensive focus on plant based extracts as antimicrobial textile finish has gained significant momentum and is an emerging technology in the production of functional textiles. The present research was intended to apply antimicrobial finish to cotton fabric using banyan leaves extract. The application of finish was performed with exhaust and pad dry cure methods and the efficacy of herbal finish was assessed after 5 and 10 wash cycles in terms of per cent reduction in bacterial count. The treated fabrics exhibited 94.62 and 93.54 per cent reduction in the bacterial count of *Staphylococcus aureus* and *Escherichia coli* after the application of banyan leaves extract by exhaust method whereas after the application of banyan leaves extract by pad dry cure method 95.82 and 95.70 per cent reduction in the bacterial count of *S. aureus* and *E. coli*, respectively was observed. 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 per cent for *S. aureus* and *E. coli*, respectively. For pad dry cure method, the bacterial count of *S. aureus* and *E. coli* of the washed fabric after 5 washing cycles decreased by 73.47 and 70.98 per cent, respectively and after 10 washing cycles, the bacterial count of *S. aureus* and *E. coli* was decreased by 62.61 and 59.72 per cent, respectively. Conclusively, banyan leaves were observed an effective natural source for imparting antibacterial finish on cotton fabric.

Keywords : Antimicrobial efficacy, bacterial count, banyan leaves extract, cotton fabric

Microorganisms are found everywhere on the earth and their growth on textile materials is a common problem. This growth can be found on both natural and synthetic textiles, which leads to several effects like unpleasant odour, staining, deterioration, degradation, and pigmentation in the quality of textile material. Natural fibres, especially cotton are highly affected by bacteria, due to the presence of cellulose, which acts as food for bacteria, whereas synthetic fibers are resistant to microorganisms due to their hydrophobic nature. To overcome these drawbacks, it is necessary to prevent the growth of microbes on textile material for providing good comfort and safety to the wearer. The process of antimicrobial finishing imparts the ability of textile materials to inhibit the growth of microorganism, like *E.coli* and S. *aureus* on the surface of the textile material. The production of antimicrobial textiles is carried out by the application of antimicrobial agents on the surface of textile material. These antimicrobial finished textiles protect both the users from pathogenic or odor generation microorganism and damage to the textile material. Recently, the demand for antimicrobial finished textiles has increased in medical, healthcare, surgical and sports activities to avoid cross infection diseases (Sadannavar *et al.*, 2021). The antimicrobial finished textiles have important functions, such as protection of textile material from the damages caused by microorganisms, protection of wearer against odor or pathogenic microorganisms and reducing the odor and pigmentation.

India has rich biodiversity and there are more than 450 plants yielding dyes and pigments. Many of these plants are classified as medicinal and some of these like *neem*, tea tree, azuki beans, aloevera, *tulsi* leaves, clove oil, pomegranate rind, turmeric, eucalyptus oil, onion, etc. have been used to impart antimicrobial finish to the textiles (Sathianarayanan *et. al.*, 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 antimicrobial 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 ecofriendly 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 planned to obtain the natural antimicrobial extract for development of microbial resistance finish for cotton fabric.

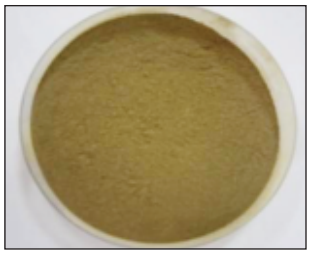
MATERIALS AND METHODS

i. **Fabric:** Plain woven, desized and scoured cotton fabric with 60x58 ends and picks/inch, weighing149.80g/m2 with relative thickness of 0.298 mm was used for the experimental work.

ii. **Preparation of fabric:** To ensure uniform wetting and make the textile substrate ready for imparting finish the inherent or added impurities and foreign materials the selected cotton fabric was desized and scoured treatments using the protocol of Jose *et al.*, 2016.

iv. **Assessment of antibacterial property of plant extract treated fabrics:** All the treated fabrics were evaluated for their

Banyan Leaves



Dried Powder

iii. Optimized parameters of bacterial resistant treatment for cotton fabric with banyan leaves extract

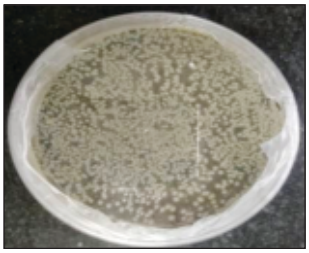
Treatment parameters	Optimized values	
	Exhaust method	Pad dry cure method
Extraction medium	Aqueous	
Extraction time (hr)	Triple percolation (24+12+12)	
Concentration of herbal extract (%)	17.0	17.0
Concentration of citric acid (%)	8.0	8.0
Treatment pH	6.0	6.0
Material to liquor ratio	1:40	1:20
Treatment temperature (°C)	60	40
Treatment time (min)	60	30
Drying temperature (°C)	110	130
Drying time (min)	5	5
Curing temperature (°C)	-	140
Curing time (min)	-	5
Curing time (min)	-	5

bacterial resistance property against two common human pathogenic bacteria, *i.e S. aureus* and *E. coliu* sing standard quantitative test method AATCC Test Method 100.

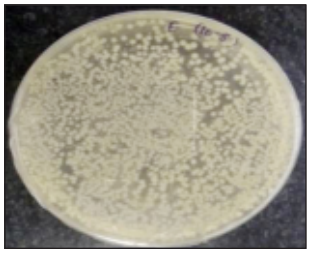
RESULTS AND DISCUSSION

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 reveal that the

Bacterial growth on banyan leaves extract treated cotton fabric untreated

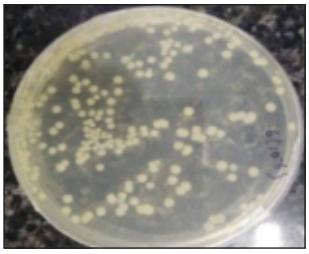


Staphylococcus aureus

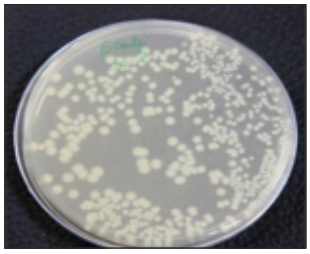


Escherichia coli

Treated by Exhaust method

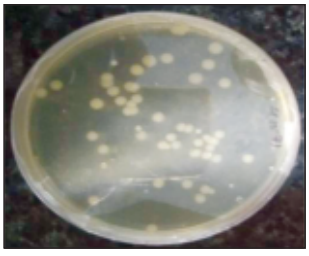


Staphylococcus aureus

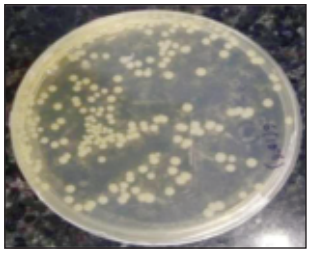


Escherichia coli

Treated by pad dry cure method



Staphylococcus aureus



Escherichia coli

bacterial count of untreated (control) fabric was 40.0x107 and 44.03x107 for *S. aureus* and *E. coli*, respectively. When banyan leaves extract was applied on the fabric by exhaust method, the bacterial count observed for *S. aureus* and *E. coli* was 2.15x107 and 2.84x107, respectively. The cotton fabric when treated with banyan leaves extract using pad dry cure method, the bacterial count noted for *S. aureus* was 1.67x107 and *E. coli* was 1.89x107.

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 *S. aureus* and *E. coli* bacteria in comparison to exhaust method of application (Table1).

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 narrates that when banyan leaves extract was applied on the cotton fabric by exhaust method, the per cent reduction in growth of *S. aureus* and *E. 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 *S. aureus* and 95.70 per cent reduction in growth of *E. coli* were observed in comparison to untreated (control) fabric. This might be due to the binding of antibacterial constituents present in banyan leaves extract with bacteria at cell surface and subsequently inhibited the growth of bacteria (Table 2).

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 plant extract was applied on cotton fabric by pad dry cure method somewhat higher per cent reduction in the

Table1: 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

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 resistancet reatment 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

growth of *S. aureus* as well as *E. coli* bacteria was observed as compared to exhaust method.

As per the findings of Mahesh *et al.*, (2011) the exhaust method of finish application was found effective and suitable. Poonia (2018) and Sushila (2018) also applied the fruit peel extract on cotton fabric by exhaust and pad dry cure methods. Yadav (2019) found that the exhaust as well as pad dry cure method are equally suitable for applying herbal finish on cotton fabric.

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 fabrics treated with herbal extract of banyan leaves by exhaust and pad dry cure methods were assessed for retention of treatment after 5 and 10 washing cycles to analyze the effect on their antibacterial properties. 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 per cent reduction in the bacterial count. The data regarding the retention of bacterial resistance property of banyan leaves extract treated fabrics after washing are presented in Table 3.

It is discerned from the Table that the fabrics treated with banyan leaves extract by exhaust method showed decrease in per cent reduction in growth of *S. aureus* from 71.68 to 68.14 per cent and from 69.09 to 63.27 per cent in growth of *E. coli* after 5 and 10 washes, respectively. When the treatment was applied with pad dry cure method decrease in the growth of *S. aureus* from 73.47 to 62.61 per cent was observed and for *E. 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 found in line with the results of study carried out by Thilagavathi and Rajenderan (2005); Orhan *et al.*, (2007); 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. Sumathi *et al.*, (2015) noticed that antibacterial properties were decreased with 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.

CONCLUSION

Antibacterial finishing of textiles using natural and ecofriendly sources is an upcoming and promising area of finishing textile substrates. The banyan leaves extract with citric acid cross linking on cotton fabrics exhibited higher antibacterial efficiency against *S. aureus* and *E. coli*. The pad dry cure method of plant extract treatment exhibited higher bacterial resistance efficacy. The findings of the study will promote the use of natural antimicrobial agents for the production of ecofriendly and sustainable antibacterial textiles.

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