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Research Paper

Utilization of plant material for antimicrobial finish on cotton fabric

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■ **ABSTRACT :** Textile researchers and industrialists face many challenges because of increasing global competition in textiles. Consumers also give the great appreciate for the high value added apparel fabrics with novel finishes. As all over the world, consumer demands for the products which have the functionality. Some of the examples of functionality are product attributes such as wrinkle resistance, soil release, water repellency, flame retardancy and resistance to microbial invasion. Among these, antimicrobial finish is considered as the important parameter for the functional textiles which find a variety of application such as health and hygiene products, specially the garments worn close to skin and several medical applications, such as infection control. The present study was undertaken with the objectives to apply the antimicrobial finish on cotton fabric, to prepare utility articles from the developed antimicrobial finished cotton fabric and calculate their cost. Extract of *Tulsi* leaves and Onion skin were used as antimicrobial agent. To apply the antimicrobial finish two methods *i.e.* direct and microencapsulation were used. After the application of finish, treated fabrics were tested under standard test method to check the percentage of quantitative bacterial reduction and qualitative assessment of antimicrobial activity. Both the methods showed good antimicrobial properties. Wash fastness results showed that microencapsulated fabric showed good antimicrobial property even after ten washes so it was found that microencapsulated fabric was more durable than the fabric treated with direct application method. Physical properties such as crease recovery, drapability, stiffness property and thickness of the fabric were also assessed. The cost of utility articles which were prepared by the treated fabric were kitchen apron was Rs. 727.5/- per piece, kitchen gloves was Rs. 1350/- per pair, napkin set was Rs. 707.5/- per piece and mask was Rs. 1331.5/- per piece.

■ **KEY WORDS:** Antimicrobial finish, Cotton fabric, *Tulsi*, Onion skin, Direct method, Microencapsulation method

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With the increase in new antimicrobial fibre technologies, a range of textile products based on synthetic antimicrobial agents such as triclosan, metal and their salts, organometallics, phenols and quaternary ammonium compounds have been developed and quiet few are also available commercially

(Bonin, 2008, Chen and Chang, 2007). As synthetic agents are very effective against microbes and give a durable effect on textiles, they also cause the side effects, action on non-target micro-organism and water pollution. Due to these side effects, there is a demand for antimicrobial textiles based on eco-friendly agents which not only help to reduce effectively the ill effects associated due to microbial growth on material but also comply with statutory requirements imposed by regulating agents. So demand of natural antimicrobial agents has greater as compared to synthetic antimicrobial agents (Thilagavathi *et al.*, 2007).

Natural variants possess more potential because of their eco-friendly nature, least toxicity, and suitability for next-to-skin innerwear and safe-handling. There are many natural products which show antimicrobial properties like *Tulsi*, onion, clove oil, *Neem* etc. Thus antimicrobial properties exhibit from the different parts of diverse species of plants like root, flower, leaves, seeds etc. Many of the plants contain compound like flavonoids, phenolic, terpenoids, alkaloids, polypeptide etc. which acting as antimicrobial. Thus these products can be used as a tool in providing antimicrobial finish to textile as they are known for their medical properties from a long time but their structures and protective properties have been recognized only in the recent years. The finishing of fabrics using natural plant products as antimicrobial agents is an emergent technology in the making of antimicrobial textile. Based on antimicrobial activity and availability clove oil, *Tulsi* leaves, onion skin, *Neem*, ajwain seed, eucalyptus oil etc. are used as natural products for making the finished antimicrobial textile material.

■ RESEARCH METHODS

The aim of the investigation for this study was to utilize the plant material for antimicrobial finish on cotton fabric and test the treated fabric under standard test methods. The methodology adopted to carry out the present study has been categorized in the following heads and sub-heads.

Raw materials used :

Fabric :

Cotton fabric was used for application of antimicrobial finish as when it comes in contact with the body offers an ideal environment for microbial growth. The fabric was purchased from the nearby local market of Allahabad.

Selection of plant materials :

Onion skin (*Allium cepa* L.) and *Tulsi* leaves (*Ocimum sanctum*) extracts were used for antimicrobial finish on selected cotton fabric. They were purchased from the local market of Mumbai.

Pretreatment of fabric :

Scouring and Bleaching :

The above two treatments *i.e.* scouring and bleaching were carried out simultaneously by using the following recipe (Table A).

Table A : Recipe for scouring and bleaching

Particulars	Process parameters
Sodium hydroxide	17.16 g o.w.f
Hydrogen peroxide	12.87 g o.w.f
Sodium carbonate	4.29 g o.w.f
Wetting agent (Soap)	2.14 g o.w.f
Temperature	100 C
Time	3-4 hrs

After this treatment, the fabric was thoroughly washed with hot water and finally rinsed with cold water. The samples were then washed with 1% acetic acid to neutralize the samples so that no further reaction takes place during finish application.

Application of antimicrobial finish :

Method of extraction:

Tulsi leaves were washed with water to remove the dust particles. Then it was dried in hot air oven at 60^0 C for about 24 hours. After that dried *Tulsi* leaves were crushed into small pieces and extracted with methanol for 10 hrs in soxhlet extractor.

In case of onion skin, it was peeled off and also dried in hot air oven at 60^0 C for about 24 hours. Then dried skin was crushed into small pieces and extracted with methanol for 10 hrs in soxhlet extractor. (Sathianarayanan *et al.*, 2009).

Fabric treatment with plant extract :

Direct application method :

Methanol extract of the *Tulsi* leaves and onion skin were directly applied on the cotton fabric by pad-cure-method. 350ml of methanol extract and 6% of citric acid as cross-linking agent was stirred completely. Then the samples immersed in stirred extract of *Tulsi* and onion

separately for 30 mins. After this samples were taken out and padded on two-bowl pneumatic padding mangle at a pressure of 2.5 psi with two dips and nips to give a wet pick-up of 85%.

Drying and curing was carried out in the chamber of dry and cure machine which was used for drying, condensation and fixation. The fabric was dried at 80^0 C for 3 min and cured at 120^0 C for 2 min. (Sathianarayanan *et al.*, 2009).

Micro-encapsulation method:

10g of acacia powder was allowed to swell for 30 min in 100 ml of hot water. Then 50 ml hot water was added to the mixture and stirred for 15 min maintaining the temperature between 40-50^0 C. 1.5g of core material (extract of *Tulsi* and onion) was slowly added under stirring condition. Stirring was continued for another 15 min and 10 ml of 20% sodium sulphate and 6 g of citric acid were added. The stirrer was stopped and the mixture was allowed to freeze to develop microcapsules. After that sample was immersed in microcapsule solution and padded through pneumatic padding mangle at a pressure of 3 psi. Treated fabric was then dried at 80^0 C for 5 min.

■ RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Functional analysis of finishes :

Quantitative Bacterial Reduction Test for antibacterial reduction (AATCC Test Method 100 - 2004)

The assessment of quantitative antibacterial reduction was carried out by testing the treated sample with AATCC test method 100. In this test method the treated sample shows the bacterial reduction of sample in percentage.

Additional test information:

- Sample size: 48mm discs
- No. of swatches used: 4
- Method of sterilization of sample: U.V. Exposure
- Neutralizer : Dey-Engley (DE) broth

The DE broth was used in disinfectant testing where neutralization of the antiseptics and disinfectants is important for determining the bactericidal activity.

The following Table 1 and Fig. 1 shows the result of quantitative bacterial reduction test.

The result clearly shows that all the treated fabrics were having good antimicrobial properties against Gram positive (Sa) and Gram negative (Kp) micro-organism. The treated fabrics do not allow the growth of micro-organism under test specimen. In control sample there was zero percentage reduction of micro-organism. Both the organisms were having good percentage reduction by *Tulsi* extract. Both the method of *Tulsi* extract application, direct as well as microencapsulation gave 94.2 per cent and 93.8 per cent of reduction for gram positive and 93.7 per cent and 94.2 per cent of reduction for gram negative micro-organism simultaneously (Sundaramurthi *et al.*, 2012).

In case of onion extract the reduction of gram positive micro-organism through direct application was 93.4 per cent and for gram negative it was 91.4 per cent. On the other hand reduction through microencapsulation

Table 1 : Assessment of quantitative bacteria reduction test

Sr. No.	Sample code	Test organism	No. of bacteria per sample (CFU)		Bacteria reduction in%
			'0' hrs (B)	'24' hrs (A)	
1.	*Tulsi* extract- Direct application	*Staphylococcus aureus*	1.56×10^5	0.090×10^5	94.2
		Klebsiella pneumonia	1.62×10^5	0.102×10^5	93.7
2.	Onion extract- Direct application	*Staphylococcus aureus*	1.75×10^5	0.115×10^5	93.4
		Klebsiella pneumonia	1.42×10^5	0.121×10^5	91.4
3.	*Tulsi* extract-Micro-capsulation	*Staphylococcus aureus*	1.57×10^5	0.096×10^5	93.8
		Klebsiella pneumonia	1.88×10^5	0.109×10^5	94.2
4.	Onion extract- Micro-capsulation	*Staphylococcus aureus*	1.38×10^5	0.124×10^5	91
		Klebsiella pneumonia	1.44×10^5	0.127×10^5	91.1
5.	Control (Untreated)	*Staphylococcus aureus*	1.36×10^5	1.45×10^7	Nil
		Klebsiella pneumonia	1.35×10^5	1.26×10^7	Nil

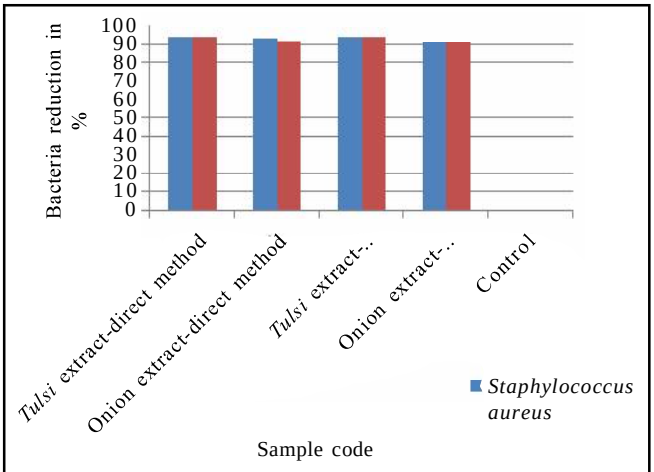

Fig. 1 : Assessment of quantitative bacteria reduction

was 91 per cent for gram positive and 91.1 per cent for gram negative (Thilagavathi *et al.*, 2007).

Qualitative method for testing presence or absence of antimicrobial activity (AATCC Test Method-147- 2011) :

The assessment of qualitative antimicrobial activity was carried out under this test method. The result of this method shows the presence and absence of antimicrobial growth on treated fabric. It was found that qualitative test was good for testing the main agents or treated fabrics, providing the antibacterial agent used were capable of leaching out.

The following Table 2 and Plate 1 and 2 reveal the presence and absence of antimicrobial activity:

The results clearly show that all treated fabrics were having antibacterial activity present against Gram positive (Sa) and Gram negative (Kp) micro-organism. Untreated fabric was having the growth of specimen present and showed the absence of antibacterial activity.

In case of all the treated fabric there was no zone of inhibition for both micro-organisms. The treated fabric with the extract of *Tulsi* and onion were having no growth of specimen which shows that antibacterial activity was present in both the application methods. The zone of inhibition value indicates that both the extracts of plant materials not only prevent the growth of bacteria under the fabric but also leaches out and kills the bacteria (Patel and Desai, 2014).

Wash durability of treated fabric :

The finished fabric was washed ten times and the

Table 2 : Assessment of antimicrobial activity

Sr. No.	Sample code	Test organism	Zone of inhibition (mm)		Result of antibacterial activity
			Zone of inhibition	Growth of specimen	
1.	*Tulsi* extract- Direct application	*Staphylococcus aureus*	No Zone	Absent	Antibacterial activity present
		Klebsiella pneumonia	No Zone	Absent	
2.	Onion extract- Direct application	*Staphylococcus aureus*	No Zone	Absent	Antibacterial activity present
		Klebsiella pneumonia	No Zone	Absent	
3.	*Tulsi* extract- Micro-encapsulation	*Staphylococcus aureus*	No Zone	Absent	Antibacterial activity present
		Klebsiella pneumonia	No Zone	Absent	
4.	Onion extract- Micro-encapsulation	*Staphylococcus aureus*	No Zone	Absent	Antibacterial activity present
		Klebsiella pneumonia	No Zone	Absent	
5.	Control (Untreated)	*Staphylococcus aureus*	No Zone	Present	Antibacterial activity absent

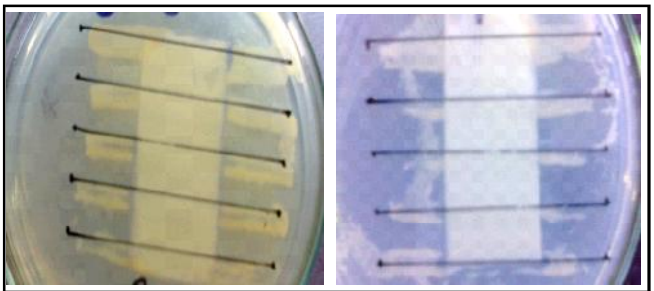

Plate 1 : The presence of antimicrobial finish on cotton fabric of *Tulsi* extract

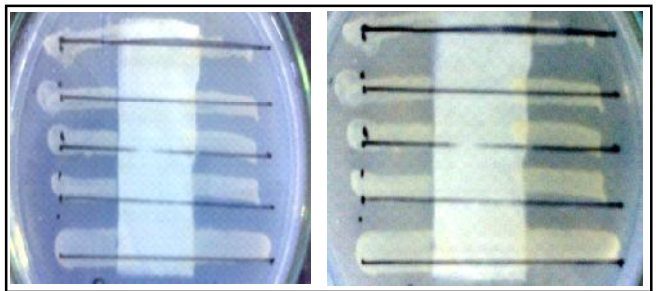

Plate 2 : The presence of antimicrobial finish on cotton fabric of onion extract

Table 3 : Wash durability of treated fabric

No. of washes	% of Bacterial reduction							
	Direct method				Microencapsulation method			
	Tulsi		Onion		*Tulsi*		Onion	
	Sa	Kp	Sa	Kp	Sa	Kp	Sa	Kp
0	94.2	93.7	93.4	91.4	93.8	94.2	91	91.1
1	30.0	22.3	28.8	20	91.7	85.4	89.7	85
3	25.4	19.2	25.6	16.5	89.2	84.2	83.5	80.9
5	21	16.3	18	11.6	88.1	83.0	78.4	76
7	11.8	8.6	9	7.4	78	75.9	62.4	69.2
10	5.6	3	4.4	3.5	63.1	51.7	56.4	52.9

Sa – *Staphylococcus aureus*, Kp- *Klebsiella pneumonia*

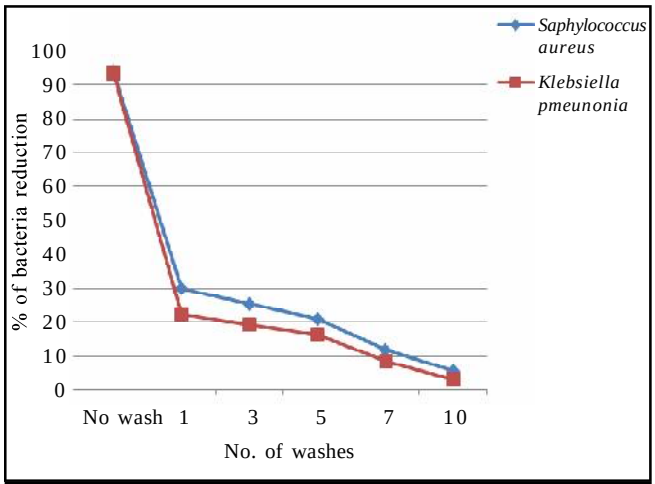

Fig. 2a : Wash durability of treated fabric with *Tulsi* extract-direct method

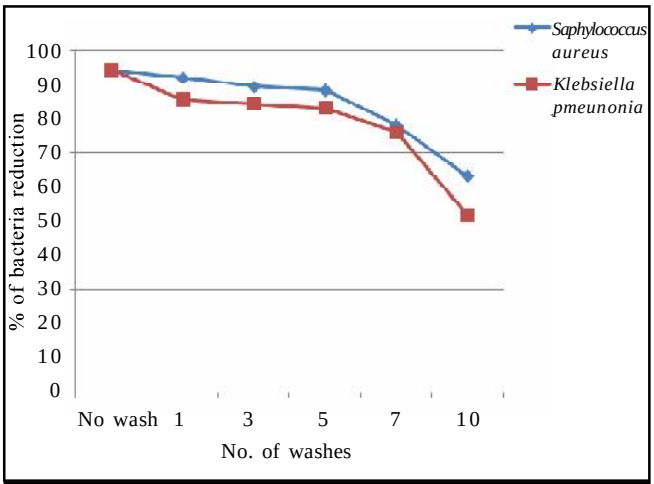

Fig. 2c : Wash durability of treated fabric with *Tulsi* extract-microencapsulation method

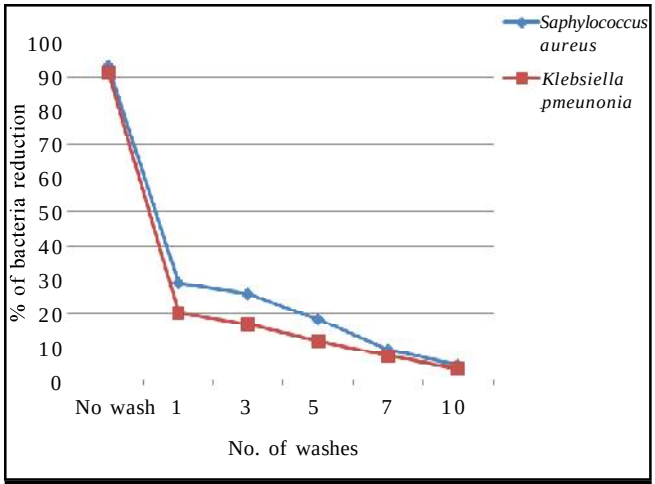

Fig. 2b : Wash durability of treated fabric with onion extract-direct method

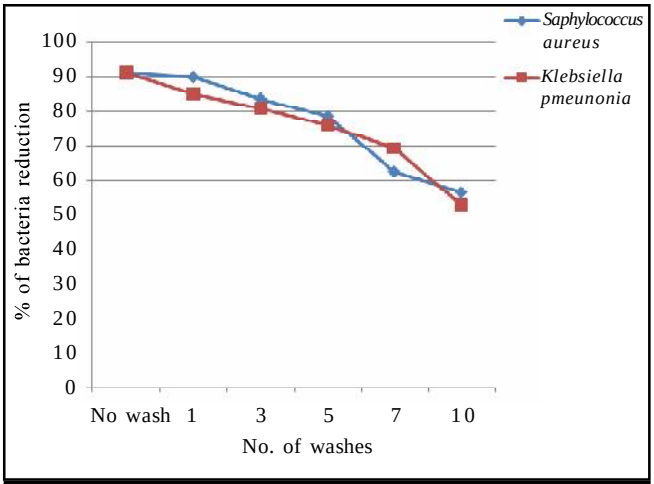

Fig. 2d : Wash durability of treated fabric with onion extract-microencapsulation method

fabric was tested for its fastness properties. The following Table 3 and Fig. 2 (a, b, c and d) shows the test results of the treated fabric samples.

Direct application of *tulsi* extract on cotton fabric showed very good antimicrobial property for both micro-organism Sa and Kp but showed poor wash durability.

Table 3 shows that before washing the treated fabric with *Tulsi* shows 94.2 per cent bacterial reduction for Sa and for Kp which get reduced after one wash to 30.0 per cent and 22.3 per cent, respectively. In case of onion it shows good antimicrobial finish for both micro-organism and before washing it shows bacterial reduction as 93.4 per cent for Sa and 91.4 per cent for Kp but after one wash the reduction value drops down and were 28.8 per cent and 20 per cent for Sa and Kp, respectively. This indicates that direct treatment was only a superficial coating on the fabric surface without a firm bonding and gets removed by washing.

The extract of *Tulsi* and onion applied through microencapsulation was found as a good resistance to bacterial attack. Table 3 shows that in case of *Tulsi* the bacterial reduction before wash was 93.8 per cent for Sa and 94.2 per cent for Kp but after one wash the reduction of bacteria was 91.7 per cent and 85.4 per cent for Sa and Kp, respectively. When the onion extract was applied the bacterial reduction was 91 per cent for Sa and 91.1 per cent for Kp but after one wash the reduction drop down and was 89.7 per cent and 85 per cent, respectively. Till 10 washes the reduction was reduced till 63.1 per cent and 51.7 per cent for Sa and Kp, respectively for treated fabric with *Tulsi* and 56.4 per cent and 52.9 per cent for Sa and Kp, respectively for onion treated fabric.

Thus the result shows that the microencapsulation treatment gives good antimicrobial property and good wash durability upto 10 washes as compared to direct method.

Physical properties of treated fabric :

The physical properties of the fabric like crease recovery, stiffness, thickness and drapability also get affected by applying the finish on the fabric. The crease recovery of the fabric was 251^0 in direct and 303^0 in microencapsulation by *Tulsi* extract and 295^0 in direct and 272^0 in microencapsulation by onion extract. Thus there is no significant difference in the degree of crease recovery in direct application method. The thickness of the treated fabric was 0.288mm by *Tulsi* extract and 1.192mm by onion extract in direct application method and 1.396mm by *Tulsi* and 1.508mm by onion in microencapsulation method. The treated fabric was much thicker in microencapsulation method as compared to direct application method.

The stiffness of the treated fabric revealed that in direct method the fabric was stiff upto 5.1cm by *Tulsi* extract and 4.1cm by onion extract. In case of micro encapsulation method the stiffness of the fabric was 8.5cm by tulsi and 6cm by onion. However the fabric which was treated by microencapsulation method was much stiffer than direct application method. The drapability of the treated fabric was resulted 68 per cent for *Tulsi* and 50 per cent for onion in direct method and 10 per cent for *Tulsi* and 12 per cent for onion in microencapsulation method. Thus drapability was depend on the stiffness of the fabric and as the result shows that the fabric treated by microencapsulation method was much stiffs than direct treated method so the drapability of direct treated fabric was good as compared to microencapsulation method.

Conclusion :

The extract of *Tulsi* leaves and onion skin were used for the application of antimicrobial finish. Both the test method *i.e.* direct and microencapsulation method showed good antimicrobial activity. Microencapsulation method showed good wash fastness properties as compared to direct method. The cost of utility articles which were prepared by the treated fabric were kitchen apron was Rs. 727.5/- per piece, kitchen gloves was Rs. 1350/- per pair, napkin set was Rs. 707.5/- per piece and mask was Rs. 1331.5/- per piece.

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