

## Antimicrobial coating of cotton twill tape with neem oil, eucalyptus oil and tulsi oil for medicinal application

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**This paper reports the development of antimicrobial finishing for cotton twill tape with essential oil extracted from eucalyptus leaves, tulsi leaves and neem seed. The inhibition was analysed against four bacterial and one yeast isolate. The washing fastness shows that fabrics treated with neem seed oil show antimicrobial effect against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Candida albicans*, till the end of the third wash, followed by tulsi oil, but lower inhibition was observed well only after the first wash. The results show the antibacterial holding capacity of cotton twill tape after repeated washes.**

**Keywords:** Antimicrobial finishing, cotton twill tape, essential oil, washing fastness.

HOSPITAL linen is the most likely way of transmitting nosocomial infections<sup>1</sup>. Contaminated textiles in health-care facilities undergo two main cleaning procedures: (i) non-microbiological processes, which help to re-establish appearance and avoid weakening; (ii) a second process of cleaning that is microbiological and help to diminish the microbial count, along with any constituents that promote their proliferation or interfere with disinfection<sup>2</sup>. The most prevalent microbial community on clinical linens are: Gram-negative bacteria, *Bacillus* spp., coagulase negative *Staphylococci* and characteristic microflora of skin<sup>3</sup>. Washing may undoubtedly remove the dirt; nonetheless it does not imply that the linens are sterile. The existence and proliferation of micro-organisms in fabrics increases the health risk which enhances the requirement for bacteriostatic coatings on clothing<sup>4</sup>. The main antimicrobial finishing used so far in textiles comprise triclosan, phenols, quaternary ammonium complexes, metal salts, organo metallics and organosilicons<sup>5</sup>.

Plants are the chief sources for complementary and alternative medical practices and each portion of the plant, including the seeds, root, stem, leaves, and fruit are essential contributors of bioactive components<sup>6</sup>. Fats and lipids extracted from the tulsi leaves and inflorescence are known to have valuable attributes, and used as anti-

emetics, cough medicine, painkillers, antipyretics, anxiety reducers, anti-inflammatory, anti-asthmatic, hypoglycemic, liver damage preventives, blood pressure reducers, lipid lowering and immunomodulatory agents<sup>7</sup>.

Similarly, another ancient medicinal plant, which has several pharmacological properties is neem (*Azadirachta indica*). Neem oil from the leaf, bark and seed is known to show extensive medicinal properties. It mainly acts as a reducing or preventive agent for oxidation, malarial infection, mutagenesis, carcinogenesis, inflammation, hyperglycaemia, ulcer and diabetics<sup>8</sup>.

*Eucalyptus globules* (*E. globulus*) is a known therapeutic plant because of its biological and pharmacological properties. The enriched presence of 1,8-cineole in essential oils is used extensively in pharmaceutical industries and leaf extracts are curative medication for many infectious diseases<sup>6</sup>.

The study on their sterile activity on fabric material is partial and not well documented. The current study mainly explores the application of antimicrobial finishing of natural essential oils from plant origin on cotton twill tape and its persistence after repeated washing.

The *Eucalyptus* (*Eucalyptus globulus*) leaves, tulsi (*Osmium basilicum*) leaves and neem (*Azadirachta indica*) seeds were collected from the nearby herbal nursery, Chennai. The leaves and seeds were shade-dried for seven days, crushed manually and then finally made into fine powder.

Steam distillation process was employed for extraction of oil from the source. The crushed leaves or seeds of 50 g were supplemented with 100 ml of deionized water, and distilled at a working temperature of 100°C for 1 h. After the distillation started, the sample starts boiling in 5 min and vapours are formed. Condenser assisted cooling of vapour was continued and the condensate was collected<sup>9</sup>. The condensate is a blend of oil and water, which was separated by the rotary evaporator. The oil was decontaminated and used as antimicrobial coating substance in cotton fabric.

The essential oils extracted from eucalyptus leaves, tulsi leaves and neem seeds were individually coated onto a freshly cleaned cotton twill tape by dip coating technique. The bulk fabric was cut into 0.5 cm<sup>2</sup> pieces. The pieces of fabrics were submersed in oil for 2.5 min and stirred in oil until a wet pick up of 85 ± 5%. It was pressed between two pieces of filter paper to remove excess liquid and then placed in a 60°C oven for 5 min to dry and 120°C for 2 min to cure the coating<sup>10</sup>.

Screening of antimicrobial activity of the extracts infused cotton twill tape was completed by Agar well diffusion method. Around 20 ml of sterile Muller Hinton Agar was dispensed into a sterile petri dish and solidified. Subsequently, 0.5 ml of fresh culture of *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Candida albicans* were swabbed on to different petri dishes and labelled. The oil infused cotton

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twill tapes of size 50 mm<sup>2</sup> (0.5 cm × 0.5 cm) were placed in the petri dish. The petri dishes were then incubated at 35°C for 24 h and the ‘zone of inhibition’ was measured. The area in the petri dish where no colonies were formed indicates the ‘zone of inhibition’. The diameter of this area is significant to understand the bacteria’s resistance to a specific antibiotic. This diameter is strongly dependent on the concentration of antibiotic, bacterial species and temperature of incubation<sup>11</sup>.

In addition, to observe the effectiveness of antibiotic effect of oil after washing, the finished fabrics were cleaned in Launder-o-meter conferring to AATCC test method 124-1975 (I I A), using a nonionic detergent, Lisapal N<sup>12</sup>.

In the present study, cotton twill tapes infused with essential oils without any chemical agents or stabilizers were developed, and their antimicrobial activity was investigated against the selected bacterial and yeast species which are prevalent in common microbial flora in hospital atmosphere, such as of *B. subtilis*, *S. aureus*, *P. aeruginosa*, *E. coli* and *C. albicans*. The maximum zone of

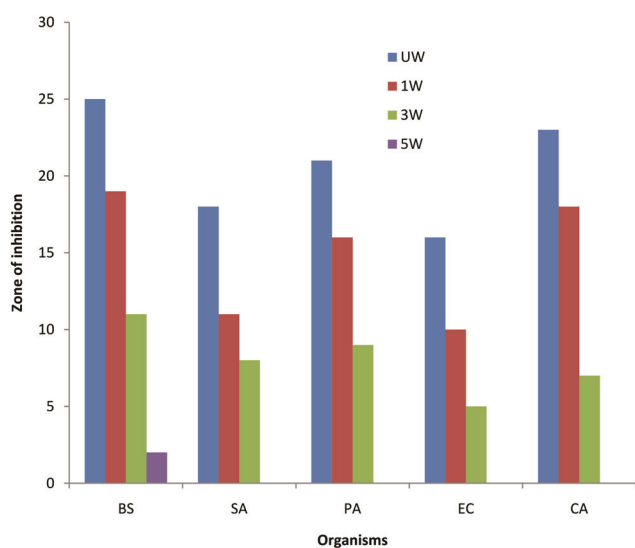
inhibition of 25 and 23 mm was obtained for neem (*A. indica*) oil infused twill tape against *B. subtilis* and *C. albicans* (Table 1, Figure 1). Upon the first wash and the third wash, the antibacterial activity persisted, whereas after fifth wash the inhibition zone was obtained only for *B. subtilis* in 2 mm diameter. Further, 300 diverse active complexes were stated from diverse portions of neem seeds. Most importantly, limonoids such as azadirachtin, salannin and nimbin have good antimicrobial activity. These compounds probably help in controlling the microbial growth even after the third wash. The pest repellent properties of neem extracts have a potential to constrain the proliferation of both Gram-positive and Gram-negative bacteria, and hence extensively employed in herbal pesticide formulation<sup>13</sup>.

Twill tapes infused with tulsi (*O. basilicum*) leaf showed antimicrobial activity of 25, 23, 18, 13 and 10 mm under unwashed condition for *C. albicans*, *S. aureus*, *P. aeruginosa*, *B. subtilis* and *E. coli* respectively (Table 2, Figure 2). After the first wash it was seen that inhibition persisted against all species. After the third wash, inhibition was only against *C. albicans*, *S. aureus*, *P. aeruginosa* and after the fifth wash there was no

**Table 1.** Antimicrobial activity of neem seed oil

Organisms	Zone of inhibition (mm)			
	UW	1W	3W	5W
<i>Bacillus subtilis</i>	25	19	11	2
<i>Staphylococcus aureus</i>	18	11	8	–
<i>Pseudomonas aeruginosa</i>	21	16	9	–
<i>Escherichia coli</i>	16	10	5	–
<i>Candida albicans</i>	23	18	7	–

Zone are mean ± SD for n = 3; –, No zone of inhibition.

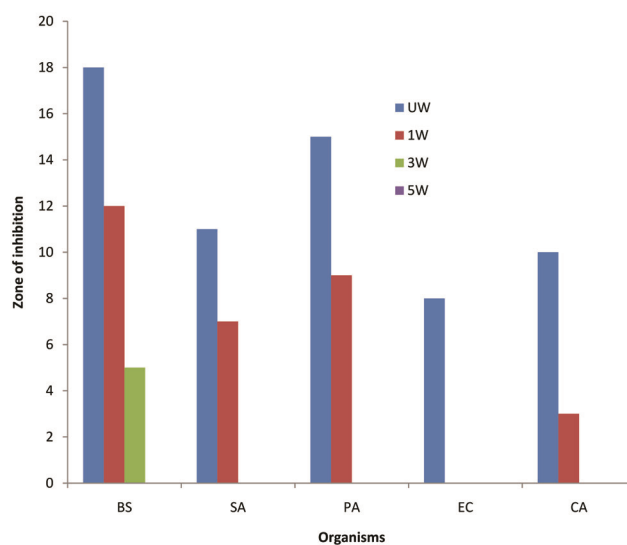


**Figure 1.** Antimicrobial effect of neem seed oil infused twill tape after different washes. BS, *Bacillus subtilis*; SA, *Staphylococcus aureus*; PA, *Pseudomonas aeruginosa*; EC, *Escherichia coli*; CA, *Candida albicans*; UW, Unwashed; 1W, After first wash; 3W, After third wash; 5W, After fifth wash.

**Table 2.** Antimicrobial activity of Eucalyptus oil

Organisms	Zone of inhibition (mm)			
	UW	1W	3W	5W
<i>Bacillus subtilis</i>	18	12	5	–
<i>Staphylococcus aureus</i>	11	7	–	–
<i>Pseudomonas aeruginosa</i>	15	9	–	–
<i>Escherichia coli</i>	8	–	–	–
<i>Candida albicans</i>	10	3	–	–

Zone are mean ± SD for n = 3; –, No zone of inhibition.



**Figure 2.** Antimicrobial effect of eucalyptus oil infused twill tape after different washes.

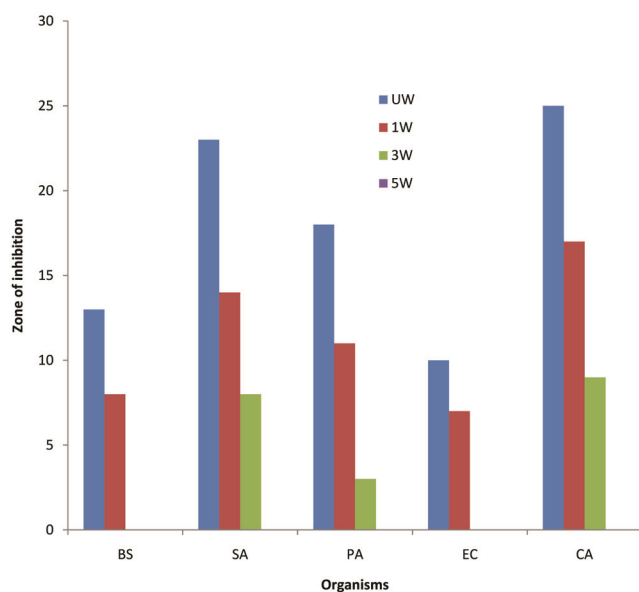
antimicrobial effect experienced. Tulsi belongs to the Labiatae family and earlier reports show that the leaves consist of 70% eugenol, 20% methyl eugenol, 3% carvacrol. These active compounds primarily act as preventive and growth inhibiting agents against bacteria, insects, and protozoa and revealed decrease in bacterial population of 73% in the challenge test. It also acts as a diaphoretic and expectorant. The bacteria-resist properties of tulsi in leaf form have also been studied and used as finishing on cotton yarn, but no reassuring results were explored after prolonged storage<sup>12</sup>.

Fabrics treated with eucalyptus oil gave the outcomes as 18, 15, 11 and 10 mm zone of inhibition for *B. subtilis*, *P. aeruginosa*, *S. aureus* and *C. albicans* under unwashed condition. The antimicrobial activity was reduced to inhibition zone of 12 mm against *B. subtilis* after the first wash (Table 3, Figure 3). Similar results were also reported earlier<sup>14,15</sup>. After the third and the fifth wash, there is no antimicrobial effect experienced. This indicates that natural binding of eucalyptus oil is comparatively weak with neem and tulsi oil<sup>13</sup>.

**Table 3.** Antimicrobial activity of tulsi oil

Organisms	Zone of inhibition (mm)			
	UW	1W	3W	5W
<i>Bacillus subtilis</i>	13	8	–	–
<i>Staphylococcus aureus</i>	23	14	8	–
<i>Pseudomonas aeruginosa</i>	18	11	3	–
<i>Escherichia coli</i>	10	7	–	–
<i>Candida albicans</i>	25	17	9	–

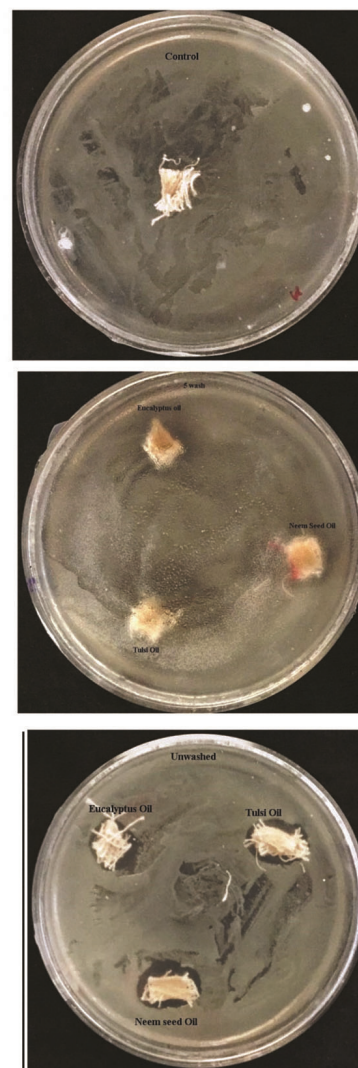
Zone are mean  $\pm$  SD for  $n = 3$ ; –, No zone of inhibition.



**Figure 3.** Antimicrobial effect of tulsi oil infused twill tape after different washes

The cotton twill tapes infused with three essential oils before unwashed condition and after different washes for different isolates were comparatively studied. The comparative analysis in antibiotic effect of oil extracts of eucalyptus (*E. globulus*) leaves, tulsi (*O. basilicum*) leaves and neem (*A. indica*) seeds as indicated by zone of inhibition is shown in Figure 4.

The results of this study have encouraged us to develop an antimicrobial finishing for cotton twill tape with essential oil extracted from eucalyptus leaves, tulsi leaves and neem seed. The washing fastness test explored the persistence of antimicrobial effect of these oils on the fabric. Fabrics treated with neem seed oil show antimicrobial effect till the end of the third wash, whereas the same for tulsi oil shows good inhibition until third wash for all isolates except *E. coli* and *B. subtilis*. Inhibition results for eucalyptus oil were found to be good only



**Figure 4.** Culture plates showing zone of inhibition of essential oil infused twill tapes against *Staphylococcus aureus* at unwashed and after fifth wash.

after the first wash. The present study shows that cotton twill tapes coated with neem seed oil possess good washing fastness for more than three washes. As a result, they are found to be in a very hygienic condition with less fungi, bacteria and microbes<sup>14</sup>. Although cotton is not commonly known as a microbial vector, in hospitals and other clinical settings it is viewed as a disease carrier. Medical fabrics infused with antimicrobial oils improve the antimicrobial properties of the fabric and can improve the market potential of the fabric.

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