Combined antimicrobial and coolant finishing treatment for cotton using yashtimadhu (Glycyrrhiza glabra L.) roots extract

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The yashtimadhu (Glycyrrhiza glabra L.) root extract was used to impart antimicrobial and coolant finishing to the cotton fabric. The extraction was done by direct extraction method using distilled water as a solvent and it was applied on to the cotton fabric by pad–dry–cure process with the optimized process conditions of Temperature -37°C, Time–4 h, pH – 7 and Concentration-50%. The fifty percent concentration of yashtimadhu root extract finished fabric showed a better zone of inhibition against Gram positive Staphylococcus aureus bacteria. The thermal resistance test results indicated that the extract finished fabric expressed lower thermal resistance value with high coolant property compared to unfinished fabric sample. The O-H and C-C functional groups present in the herbal extract also proved the characteristics of higher absorbency and thermal property by FTIR, Wetting and Wicking tests. The 50% concentration of yashtimadhu extract finished fabric exhibited better thermal resistance and antimicrobial activity and the fabric retained the finishes after 15 wash cycles.

Keywords: Antimicrobial, Coolant Finish, Yashtimadhu, Glycyrrhiza glabra, Cotton fabric, Staphylococcus aureus, Eye Syndrome.

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Introduction

Textile materials are vulnerable to microorganisms attack which would cause many cross infections and allergic reactions to the wearer. The microorganisms can deteriorate the performance properties of fabrics and produce discomfort to the wearer. Comfort is a pleasant state of physiological, psychological and physical harmony between a human being and the environment. The controlling of microorganisms is a tedious process; washing can only arrest the microorganisms but does not destroy them. “Control of microbial growth” may be achieved using physical or chemical agents that either kill microorganisms or inhibit their further growth. In order to protect the wearer from such infection, the textile fabrics can be finished with antimicrobial agents. Now, there is a good deal of demand for the fabrics having functional/specialty finishes in general but antimicrobial finishes in particular to protect human being against microbes. As consumers have become more aware of hygiene and potentially harmful effects of microorganisms, the demand for anti-microbial finished clothing is increasing.

Basically with a view of protecting the hygiene in the textile substrate, the anti-microbial finish, is a recent innovation in finishes used for health care applications. With this threat gaining its stature day by day, there is a wide variety of commercial anti-microbial agents available in the market but it gives toxic effect to the environment and the wearers. The consumers are now increasingly aware of the hygienic life style and there is a necessity and expectation for a wide range of textile products finished with eco-friendly antimicrobial properties. Eco-textiles gain utmost importance as one of the most useful resources that help to promote new innovations, in an eco-friendly manner. A medicinal herb has curative properties due to presence of various complex chemical substances with different composition, which are found and act as secondary plant metabolites in one or more parts of the plants. The various studies and literature have shown that yashtimadhu herbal extracts has numerous properties like antimicrobial, antifungal, coolant and wound healing. Therefore, in this study, the possibility of using yashtimadhu root extract with the Box and Benken optimized process parameters for giving antimicrobial and coolant finishes to the cotton fabric has been explored.
Materials and Methods

Fabric
Plain, 100% cotton woven fabric with 76 ends/inch and 52 picks/inch was desized (0.5% H₂SO₄), scoured (3% NaOH) and bleached (3% H₂O₂) prior to the application of antimicrobial finish.

Preparation of plant extract
Yashtimadhu (Glycyrrhiza glabra L.) was the plant species chosen for the study. The roots of yashtimadhu were shadow dried and made into a fine powder. 10 g of the yashtimadhu root powder was then dissolved in 100 mL of distilled water and kept for 24 h. It was then sonicated for 5 h to facilitate the complete extraction of the ingredients.

Finish application
The temperature, time, pH, concentration and the M:L ratio were optimized using the Box and Benken statistical method. Based on the various trials, the optimised conditions were Temperature -37°C, Time – 4 h, pH – 7 and Concentration – 50%. The herbal extract was applied on to cotton fabric at the material liquor ratio of 1:10 by pad - dry cure method using pneumatic padding mangle with standard conditions. The mordant alum was used as a binding agent to fix the herbal extract on to fabric. The treated fabric sample was then dried at 80°C for 10 minutes to remove the moisture. Finally the fabric samples were tested for antimicrobial activity as per the standard test methods.

Testing of Coolant Finish Efficacy (Thermal Resistance) of fabrics
The treated and untreated samples were tested under the standard test methods like the thermal resistance testing (ISO-11092), wicking and wettability tests.

Testing of antimicrobial efficacy of fabrics

- AATCC-100-1998 (USA): Quantitative - broth dilution test

  The 5 cm × 5 cm samples were prepared from the G. glabra (untreated and 50% treated) extract. 500 mL Erlenmeyer conical flasks containing 50 mL of nutrients broth were prepared and sterilized at 121°C for 15 minutes. It was then allowed to cool. The fabric samples were then transferred aseptically into the conical flasks, respectively. These were incubated at 37°C for 24 h in shaker at 121 rpm. After incubation their absorbance values were measured at 600 nm.

- AATCC-147-1998 (USA): Qualitative -Agar diffusion test

  The 50 mL of nutrient agar was prepared and sterilized at 121°C for 15 minutes. Petri plates were autoclaved in hot air oven at 121°C for 30 minutes. 20 mL of nutrient agar was poured into each of these plates and were allowed to solidify. A series of 8 test tubes containing 4.5 mL of sterile water was taken. 0.5 mL of culture from nutrient broth containing the 50% treated samples was transferred aseptically into the first test tube. Serial dilution was carried out until its reduced dilution was 10^-8. 100 µL of 10^-8 diluted culture was taken aseptically and poured onto the petri plates. This was spreaded by using L rod. The plates were incubated at 37 °C for 16 h. Similar procedure was carried out for untreated sample. The bacterial zone of inhibition was clearly noted and recorded.

FT-IR (Fourier Transform Infrared Spectroscopy) Test

FT-IR is the best choice to detect the surface composition of flavonoids structure and shows the bondage of functional groups. The compounds responsible for the antimicrobial property are identified and quantified by the FT-IR analysis. In...
the treated samples, infra red spectra were recorded on a Nicole 5DX system FT-IR spectrophotometer. The type of compounds which were present in the extracts was identified by different wavelengths. The FT-IR Graph representing the corresponding curves and wave lengths for different functional groups present were recorded.

**SEM (Surface Morphology) study**

The SEM study is mainly used to identify the finished molecules present in the fabric sample. The herbal finished and unfinished samples were analyzed using high resolution Scanning Electron Microscope. JEOL M JSM-6360 with 3-6 KV accelerating voltage was used to conform the binding of microcapsules and alignment onto the fabric sample. The herbal finished sample was examined under different magnifications using light microscopy with image processing technique to analyze the morphology of structures. The scanning was done for thirty minutes for each sample with four different magnifications depending on the thickness of the sample and the images were pictured.

**Durability of antimicrobial finishing**

The wash durability test was conducted for the treated fabric sample size of 4 × 4 cm. The treated sample was under gone for 1-25 wash cycles in a standard temperature of 37ºC and 5% standard detergent in the fully automatic washing machine as per the standard norms.

**Results and Discussion**

**Thermal resistance**

The thermal resistance value of 50% conc of *G. glabra* finished and unfinished samples are given in the Table 1. Lower the thermal resistance values represent higher the coolness property. The thermal resistance of unfinished fabric is 0.0161 (sq.m k/watt) and yastimadhu finished fabric is 0.0075 (sq.m k/watt). From the results we can conclude that the 50% conc of yashtimadhu finished sample has higher coolant property when compared to the unfinished fabric, since it has the lowest value 0.0075 (sq.m k/watt).

The wetting process calculates the amount of fiber-air interface replaced with a fiber- liquid interface was calculated. From the test results, the wettability of the herbal finished fabric was increased a considerably amount when compared to the unfinished fabric as shown in Table 2.

Table 3 also reveals that the wicking test method determines the liquid absorbent capacity of protective and functional fabrics using gravimetric principles. From the test results, the wickability of the herbal finished fabric has been increased a considerable amount when compared to the unfinished fabric.

**Antimicrobial efficacy of the finished fabrics**

The antimicrobial properties of materials can be studied by quantitative (AATCC-100) as well as qualitative (AATCC-147) test methods. Absorbance of the sample is directly proportional to the concentration of the cells in the sample. The absorbance values of the finished and unfinished
samples were compared. It was found that the herbal finished fabric gives low absorbance value (0.62) when compared to the unfinished fabric (1.03). The herbal finished fabric exhibited high bacterial reduction percentage (39.80%) against Staphylococcus aureus Gram positive bacteria. This is due to that antimicrobial agent gets attached to the substrate through bond formation on the surface. The attached antimicrobial agent disrupts the cell membrane of the microbes through the physical and ionic phenomenon. After incubation, the plates were observed for bacterial growth, the numbers of colonies were counted for each plate. The herbal finished fabric showed better zone of inhibition value (18 mm) compared to unfinished fabric (0 mm). The herbal finished fabric showed very good antibacterial property against Staphylococcus aureus microorganism and also does not support the growth of bacteria under the test conditions.

The results of FTIR stated that the herbal finished fabric possess functional group frequency peaks at 3417.98 and 1055.10 which confirm the presence of O-H bond and C-C bonds and antimicrobial flavonoids, tannins and caryophyllene compounds, respectively. The O-H bond represents the higher absorbency and C-C bond exhibits the characteristics of thermal property.

The scanning microscope pictures clearly show the bondage between the fibre structures and penetration of herbal capsules into the surface of the pad dry finished samples. The unfinished sample show maximum pore size and clear structure with a large number of protruding fibers. The morphology of yashtimadhu finished sample clearly depicts the penetration of herbal extract solution into the fabric surface alignments, bondage between the fibre structures and space between the fibers molecules.

The durability of the finishing reveals that the fabrics finished with herbal extracts are found to have good thermal resistance and also better resistance to microbial growth. In the cases of finished fabric, in each wash cycle the antibacterial activity decreases gradually and at the end of 15th wash cycle the % reduction value reaches to 0.99 are shown in the Table 4. At the same time, such herbal finished fabrics can withstand the durability of finishes up to 15 wash cycles.

Conclusion
Today the world is moving in to the eco-friendly era. There is a vast resource of natural antimicrobial agents, which can be used for imparting useful antimicrobial property to textile substrates. This research work has given a new idea in finishing of cotton with yashtimadhu (G. glabra) root extracts to enhance the multi-functional antimicrobial and coolant property. The fifty percentage concentration of yashtimadhu root extract treated fabric showed better zone of anti-microbial property against S. aureas bacteria and coolant property than untreated fabric sample. The treated fabric is found to be very hygienic and also softer after the finishing treatment. The SEM analysis shows the penetration herbal molecules and FT-IR reveals the antimicrobial compounds in the herbal finished sample. The objective evaluation tests also states that wickability and wettabilty have also increased after finishing when compared to unfinished control samples. The yashtimadhu extract finished fabric showed the better coolant and antimicrobial effects and it exhibits the natural dyeing property with an excellent yellow shade and good resistance to washing up to 15 cycles. The use of yashtimadhu extract provides

<table>
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<th>S.No.</th>
<th>Warp direction</th>
<th>Weft direction</th>
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<tbody>
<tr>
<td></td>
<td>Unfinished Fabric</td>
<td>50% concentration Yashtimadhu extract finished fabric</td>
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<tr>
<td>1</td>
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<td>3.5</td>
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<tr>
<td>2</td>
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<td>3.7</td>
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<tr>
<td>Mean value</td>
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<table>
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<th>Samples</th>
<th>Number of washes</th>
<th>Absorbance value (at 670 nm)</th>
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<td>50% Concentration Before wash</td>
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<tr>
<td>Yashtimadhu extract After 5 wash</td>
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<tr>
<td>finished fabric After 10 wash</td>
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<td>After 15 wash</td>
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<td>After 20 wash</td>
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<tr>
<td>After 25 wash</td>
<td>1.19</td>
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antimicrobial finishing in addition to its coolant finishing to the treated textile materials in a single process and this duel finish is very much cost effective and user–friendly to the wearer.

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References