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Greenly prepared antimicrobial cotton fabrics using bioactive agents from Cupressaceae pods

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Antimicrobial fabrics have become essential in organizing and managing infestation and reducing odor formation by microbes. Various green sources add antimicrobial properties to fabrics, particularly cotton. However, the major problem with microbial fabrics is the reduction in antimicrobial activity after each wash. Cupressaceae pods have shown natural potential as an antimicrobial agent in herbal medicine. This study utilizes Cupressaceae for incorporating antimicrobial properties in cotton fabrics. After methanolic extraction of the Cupressaceae extract, it was applied to cotton fabrics. The application of the extract to cotton fabrics was performed by optimizing concentration, temperature and pH parameters. The extract-modified cotton showed the best performance at a 15 wt.% concentration, 140°C and pH 7.5. The treated fabrics were tested in the presence and absence of a binder using the standard washing method ISO 105-C10:2006. The mordant-treated fabric retained 16.4% more activity after 20 washes. Finally, the antimicrobial activity of the greenly developed antimicrobial cotton fabrics was checked against *Staphylococcus*, *Escherichia coli*, *Bacillus* and *Candida albicans* by using the AATCC 100-2004 test method. The study indicated that the prepared cotton fabric showed better antimicrobial activity against the earlier mentioned strains, except for *C. albicans*. The prepared antimicrobial fabric showed a wide range of antimicrobial activities and a lower fungal activity. Thus, the prepared fabric can be used for wound dressings, hospital staff gown material and athlete's sportswear to prevent microbial infection.

Keywords: antimicrobial finishing/bioactive agents/cotton fabrics/Cupressaceae pods/green chemistry/green coatings/UN SDG 3: Good health and well-being

1. Introduction

The importance of antimicrobial materials extends beyond their use in healthcare to various aspects of daily life.^{1–4} Microbes damage the fibers of textile goods, particularly in the medical field,⁵ including surgical gowns, composites, recovery items and undergarments.^{6–8} Fabric degradation is caused by bacteria, fungi and mildew, in the form of odor, discoloration and decay.⁹ The use of antimicrobial treatments on textiles, particularly cotton, inhibits the growth of microorganisms, and it is gaining popularity because it has many hygienic and medicinal benefits.^{10–12} Hospitals and medical centers are the main places where antimicrobial fabrics can be utilized, as professionals are particularly vulnerable to contamination from a wide variety of pathogens.^{13,14}

Natural, synthetic and even animal sources have been used for antimicrobial finishing, but to achieve the best overall effect, it

should be able to work in any environment.^{15,16} In previous decades, it has been revealed that plants can be a good source of compounds with antimicrobial activity.¹⁷ Aloe vera was one of the first to be used as an antibacterial treatment¹⁸ and has now become one of the most popular botanical sources of antimicrobial products. Pomegranate has long been revered for its antibacterial properties, but the chemical composition of citrus fruits such as lemons and oranges lacks a good antibacterial activity.¹⁹ Mostly, dyes and pigments from natural sources, particularly plants, are non-toxic and safe for humans. They are often antimicrobial, as they are made up of compounds such as phenols, quinones, flavonoids, lectins and polyacetylenes.^{11,20} Plants use these chemicals to defend against invading bacteria, fungi and viruses.²¹

South Asia, particularly Pakistan, is primarily an agricultural zone, and due to the booming seasonal economy, they produce a