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Effect of Antimicrobial Finish on Aesthetic Properties of Polyester Fabric

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ABSTRACT: *Antimicrobial fabric is suitable for providing protective covering to the medicinal industry, army uniform, casual wear, and household furnishing as well as for general public usage. The environmentally friendly antibacterial finish was extracted from leaves of Azadirachata indica, Butea monosperma and Litchi chinensis trees leaves and then applied on 100% polyester. Before and after applying the antimicrobial finish, fabric property was checked. The antimicrobial finish was applied by the pad dry cure method and the finish was fixed by using of polyurethane binder. Under aesthetic properties, stiffness and surface appearance were checked. The stiffness of the fabric was checked by Shirley Stiffness tester and surface appearance was checked by using AATCC Technical Manual /2004 TM 124-2001 203 test method. The aesthetic properties (smoothness, surface appearance) of the antimicrobial finish had a positive effect on 100% polyester. Results showed that using an antimicrobial finish made from the leaves of A. indica, B. monosperma, and L. chinensis reduced the amount of bacteria on polyester fabric by 100% when compared to the control group. The result showed that antimicrobial finish increased the stiffness while smoothness appearance was decreased in case of A. indica and B. monosperma and increased in case of L. chinensis.*

Keyword: Pad dry cure method, Stiffness tester, Skin problems, Aesthetic property

INTRODUCTION

Now a days textiles are used to develop commercially available bioactive fibers and fabrics. The demand for bioactive or antimicrobial fabrics has increased as people's awareness of health and cleanliness has grown (Uddin, 2014). A cloth with a bioactive finish serves two purposes. It protects the wearer from germs as well as to protect the fabric from mold, fungus, and mycological bio deterioration (Moloney, 2016). Worldwide, research is being conducted with a focus on new quality standards, such as retaining the product's core functionality while using an environmentally responsible manufacturing approach (Purwar and Joshi, 2004). Microorganism development and growth are favored in textile (Sadaf et al., 2017). The demand for antimicrobial finishes has increased not only for local people but also for researchers and industries (Varesano et al., 2011). Antimicrobial finishes that provide protection and comfort are very important. These finishes should be resistant to flame, UV barrier and antimicrobial finishes (Cloud et al., 2013). Silver compounds are used as a chemical agent for antibacterial activity in the fabric manufacturing (Simoncic, 2016).

The eco-friendly antibacterial treatment replaced the synthetic antimicrobial agents which are harmful for the skin (Joshi et al., 2009). The ammonium salts, reactive cationic dyes and encapsulated nanoparticle agents are applied on fabric as antibacterial treatment (Rakesh et al., 2022). The novel functionalities require the demand for different antimicrobial finishes especially in textiles (Hu et al., 2012). In textile industries, different chemicals are used. The use of these chemicals can be hazardous. Awareness should be given to industrials and consumers, antibacterial finishes should be used in textile industries (Rose et al., 2020).

The development of diversity in textiles requires more demand for hygiene and cleanliness. All over the world the demand is very high. So, antimicrobial finishes should be applied in order to prevent microbial proliferation in textile (Sadaf et al., 2016). Textiles' utilitarian protective characteristics, as well as their aesthetic appeal, are well known among customers today. Nanoparticles are being used for specialty finishing in fabric production and engineering. With technological advancements, it is now feasible to synthesize nanoparticles of any size and form with a variety of functional capabilities. Nanoparticles have been used for antibacterial, UV

protection, flame resistant, and hydrophilic and hydrophobic textile treatments, according to reports (Salem et al., 2022). Microbes constitute a potential hazard to people, and they are also developing resistance to antimicrobials (Banerjee et al., 2011). As a result, new and long-lasting antibacterial compositions are required. Metallic nanoparticles have the capacity to enter and disrupt cell membrane structures, ultimately resulting in cell death. Nano-finished textiles might be used in a variety of medicinal and sanitary applications (Simoncic and Tomsic, 2010). Different microorganisms have different microbial activity that can be divided into biocides and biostats (Gao and Cranston, 2008). The objective of this research was to investigate the effect of antibacterial characteristics on polyester fabric against three plant leaves. In contrast to metallic (silver) and synthetic compounds, the usage of these plants was less expensive (such as triclosan). The research was conducted in the field of textiles using eco-friendly (natural) products in order to determine the alternative to synthetic antimicrobial fabrics. Antimicrobial properties of natural plants (*A. indica*, *B. monosperma*, and *L. chinensis*) may lead to the development of protective garments for people.

MATERIALS AND METHODS

The leaves of three plants, *A. indica*, *B. monosperma*, and *L. chinensis* were used to develop antimicrobial finish which was then applied to 100 percent polyester woven in twill weave pattern. All the investigations were carried out in standard testing environment having controlled temperature and humidity. Quality of 100 percent polyester fabric was assessed by a prominent researcher and the pH of the cloth was 7 (neutral). Antimicrobial plants were the independent variable while fabric properties i.e. fabric stiffness and fabric smoothness appearance were dependent variables.

Fabric Preparation

100% polyester cloth was washed using 4g/l detergent which was then immersed in washing solution for 1 hour. Afterwards, bleaching of the fabric was conducted at 90 degrees Celsius.

Leaves Extraction

The leaves of three trees were obtained from a botanic garden of Government College University, Lahore and were cleaned before being dried in the shade for two months. Once dry, the leaves were ground into a fine powder using a stainless steel grinder and stored in airtight high-density polyethylene

containers. Each type of dried leaf powder weighed half a kilogram as shown in fig. 1.

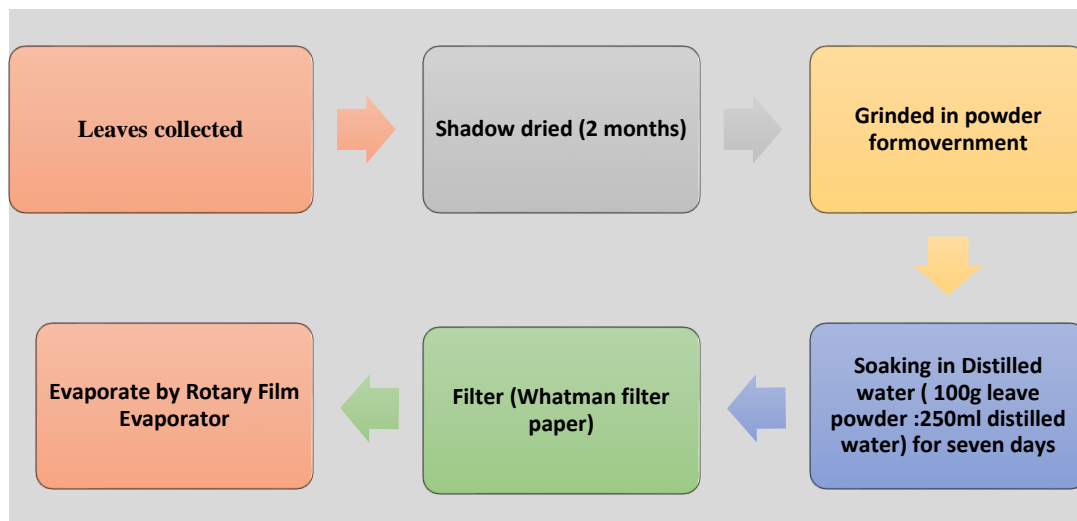


Fig. 1. The extraction process carried out for all three types of leaves

During the experiment, various microorganisms were discovered and investigated. The Gram-positive microorganisms included tiny, thick rods, clusters, cocci, and coccus clusters, while the Gram-negative microorganisms included thin, short rods, diplococci with rounded tails, coccus, coccus bacilli, coccus diploid, and yeast. All microorganisms were examined under standard settings.

Binder Application

Polyurethane binder was applied to increase the wash ability of antimicrobial finish. To investigate the antibacterial properties of binder, 10ml polyurethane binder was diluted in 90ml distilled water and then this solvent was applied on one

piece square cotton cloth by using Pad – dry-cure machine. Afterwards, Shake Flask Process (ASTEM E2149) was applied which revealed that the binder does not have any antibacterial properties. As a polymeric finishing agent, a somewhat yellow polyurethane binder was employed having the pH from 4.0 to 5.0, which was resistant to hard water, mild acids, and alkalis.

Fabric samples were cut into one-inch squares to test the antimicrobial properties of plant leaf extracts on cotton fabric. One random sample was chosen as the control group (untreated), while one sample of cotton fabric treated with each plant leave extract, was taken as the experimental group. The tests were

conducted in a Laminar Air Flow hood. To assess the presence of antibacterial properties in the treated and untreated samples, a quantitative evaluation was conducted using the ASTM E2149 Shake Flask Method. The autoclave was set at 110 degrees Celsius for the screening process.

Aesthetic Properties

Aesthetic property such as stiffness was tested using Shirley Stiffness tester complies with ISO 9073-7. For that, fabric strips of 6 x 1 inch were cut and

the sample was placed on the Shirley stiffness tester underneath the template. At either end, each sample was examined three times to find the mean value, while the readings were taken by turning the strip over.

The surface appearance of the fabric samples was evaluated using the AATCC Technical Manual /2004 TM 124-2001 203 test technique. The smoothness of the fabric surface was used as the determining factor for surface appearance.

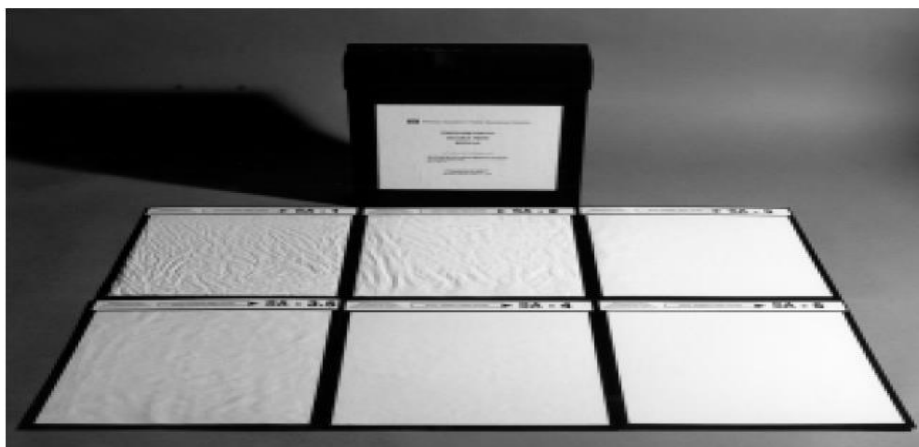


Fig. 2. AATCC 3-D smoothness appearance replica

For this evaluation, a 15 by 15 inch piece of cloth was cut into three prototypes and subjected to five home washes. Three trained observers then examined the samples using a standard reproduction in standard light and rated them individually. The observers were positioned about a distance of four feet from the panel where the testing

specimens and standard models were placed for comparison. An overhead brilliant light was used as the source of illumination, while all other lights in the room were turned off. The samples were numbered according to their resemblance to the standard replicas as SA 5 –SA 1 by the degree very smooth, smooth, mused, rumpled, and crumpled.

RESULTS

Effect of Antibacterial Treatment on Aesthetic Property

Two properties were checked in Aesthetic cloth property i.e., stiffness and smoothness appearance. This property

was checked of polyester cloth. Results showed that using an antimicrobial finish made from the leaves of *A. indica*, *B. monosperma*, and *L. chinensis* reduced the amount of bacteria on polyester fabric by 100% when compared to the control group.

Table 1. Effect of Antibacterial Treatment on Stiffness and Smoothness appearance of Polyester Fabric (Multivariate and Univariate Analysis)

Variables	Plants		
	F	P	η^2
Multivariate	2.01	.138	.84
Univariate			
Stiffness Wrap (cm)	15.79	.001	.86
Stiffness weft (cm)	9.29	.006	.78
Stiffness warp+ weft (cm)	23.799	.000	.817
Smoothness Appearance (SA Replica)	1.00	.44	.27

The table 1 shows that there is a significant difference in antibacterial treatment stiffness (weft=.006 & warp=.001) on polyester cloth, with a big effect size ($\eta^2=.86$) ($\eta^2=.78$), on the other hand on smoothness there is no effect.

When observing result of both (weft + warp) the result of F test revealed that antibacterial treatment had a significant effect, with a considerable effect size ($\eta^2=.817$).

Table 2. Polyester fabric treated and control group

	Control Group		<i>A. indica</i>		<i>B. monosperma</i>		<i>L. chinensis</i>	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Stiffness wrap (cm)	3.29	.40	4.08	.42	5.23	.70	5.05	.42
Stiffness weft (cm)	3.09	.29	2.89	.15	3.25	.33	3.54	.51
Stiffness warp+ weft (cm)	3.19	.34	3.49	.28	4.24	.50	4.30	.44
Smoothness Appearance (SA Replica)	4.00	.50	3.50	.50	3.50	.50	4.00	.50

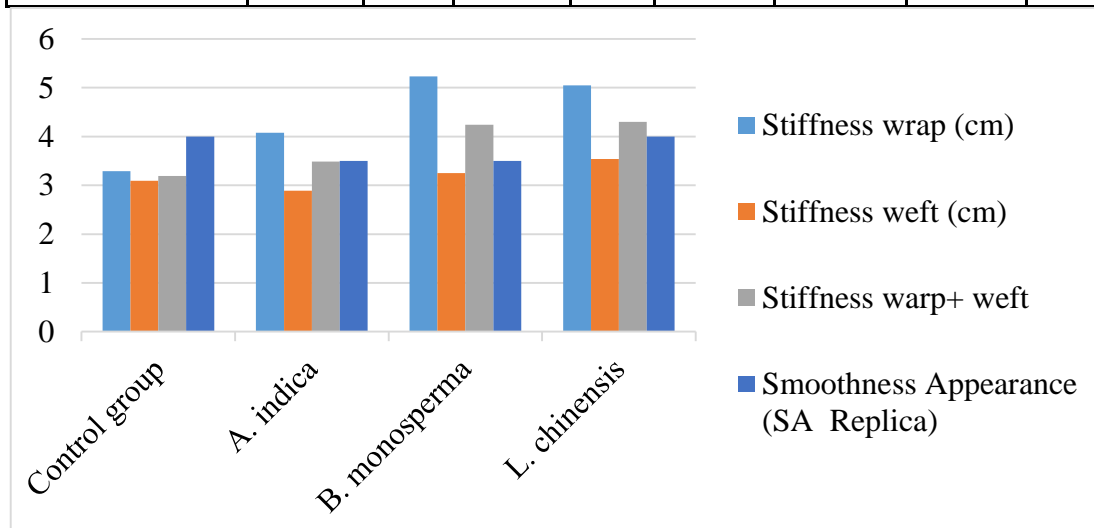


Fig. 3. Comparison between stiffness and smoothness appearance

The table 2 showed the effect of plant wise antimicrobial treatment on both fabric properties. The detail of each reading was provide in table and its overall view shown in figure 3. The readings of control group were compared

with treated groups. The readings shows that the difference in antibacterial treatment on stiffness of polyester fabric warp control group (M=3.29, SD=.40) and *B. monosperma* (M=5.23, SD=.70) was statistically substantial bestowing to

one way ANOVA ($F=15.79$, $p=0.001$, $2=0.86$). In the same way the results of *A.indica* and *L. chinensis* of stiffness warp can be observed from the table. In case of weft the control group ($M=3.09$, $SD=.290$) and *B. monosperma* experimental group ($M=3.25$, $SD=.33$) was statistically substantial ($F=9.29$, $p=0.006$, $2=0.78$), according to one way ANOVA. The overall result showed that the readings of control group were much lower warp, weft and (warp + weft) as compared to the experimental group. In case of smoothness appearance the reading of control group ($M=4.00$, $SD=.50$) is same as *L. chinensis* but in case of *A. indica* and *B. monosperma* mean value was different and standard deviation value was same, which showed that *L. chinensis* did not effect on smoothness appearance while *A. indica* and *B. monosperma* have significant effect. The result shows that antimicrobial finish increased the Stiffness while smoothness appearance was decreased in case of *A. indica* and *B. monosperma* and increased in case of *L. chinensis*.

DISCUSSION

In this study antibacterial finish was developed by use of *L. chinensis*, *A. indica* and *B. monosperma*. In another study result showed that use of herbs including neem and tulsi had a great

affect as an antimicrobial finishes. They have a positive affect against *Escherichia coli*, so the result of this study support the current study(Shalini and Swati, 2012).

Antimicrobial finishes provide protection against viruses and bacteria (Karim *et al.*, 2020). Different antimicrobial and UV protection finishes are used in cotton materials. These finishes were made by use of water . It was observed that this finish had a positive role against bacteria on cotton fabric (Yadav *et al.*, 2006). In a study the cloth was coated with nanoparticles including metallic silver copper alloy. These nanoparticles were tested against bacteria and fungi and proved to affective in formation of pilling and resistance to abrasion as well as against microorganisms presence, the result of this study support the result of current study (Kowalczyk *et al.*, 2015).

In another study, using Poly-ether-ether-ketone (PEEK) as a dental implant or abutment reduced the likelihood of failure while also improving aesthetics was determined. Given that one in every 15 patients develops an adverse response to antibiotics, photodynamic therapy (PDT) is gaining popularity as a therapeutic option (Murugesh and Ravindra, 2015). Material analysis, biofilm formation assays, and cell viability experiments were used to

examine the sollicitation of PEEK dental implants. The biofilm removal experiment was used to assess the potential utility of PDT for peri-implant mucositis. PEEK was shown to be substantially less favorable to the production of biofilms with *S. mutans* ($p < 0.001$) than the other materials, but had equivalent MG-63 (hominid osteoblast-like) osteoblast cell survival ($p > 0.05$). PDT exhibited antibacterial effectiveness and biofilm reduction benefits that were comparable to drugs. Overall, our data imply that PEEK has appealing properties and might be used as a replacement material for dental implants and abutments. PDT can be employed as an accessible treatment method in situations of peri-implant mucositis (Bhandari, 2022).

The microorganisms *Staphylococcus aureus* and *Escherichia coli* were tested for antibacterial activity. The inclusion of silver nanoparticles affected the humidity action of the examined microbes regardless of the embedment approach. The PNCS agent has proved as antibacterial which also control the pH and temperature against *E. coli* (>99%) and *S. aureus* (>85%) (Peng et al., 2021). Natural and synthetic antimicrobial finishes have some potential against microbial contaminations (Payne et al., 1996).

Another research analyzed the effects of moisture management finishes (MMF) and antimicrobial finish (AMF) on the moistness control properties of various knitted fabrics. The use in product of textiles has also increased in medical field (Cheung *et al.*, 2021). For great demand in use of antimicrobials due to their biological activity against microbes, the research on their assessment has also increased (Windler et al., 2013). Two knit fabrics (100/100 % Polyester/Nylon) with three diverse GSM values (100, 130, and 160) were chosen for the investigation. The study also included two different types of commercially available functional fabric treatments. The results demonstrate that when the cloth GSM grows, the figure of the accumulative one-way transport index (OWTI) percent upsurge, as does water vapor permeability, while at the same time, the drying rate increases. The results demonstrate that, at a given concentration level, as the fabric GSM grows, the value of the accumulative one-way transport index (OWTI) percent falls, water absorption reduces, but the drying rate increases at the same time. Knitted textiles made of (100/100 % Polyester/Nylon) follow the same pattern. The OWTI percent and water vapor permeability (WVP) factor decrease when the fabric finish

concentration level rises, while the drying rate rises (Guru et al., 2021). In other study tulsi and onion leaves were used as an antimicrobial finish. It was shown that these finishes had a great effect on bacteria in textile industry (Kirti et al., 2018). The majority of inorganic antimicrobial compounds are toxic, have a high propensity for environmental degradation, block a narrow spectrum of bacteria, and have poor laundering durability; however, organic antimicrobial agents have fewer side effects (Morris and Murray, 2020). Nanoparticles have enhanced the efficacy of several currently used antimicrobial treatments and decreased the environmental difficulties connected with these chemicals (such as toxicity and washing durability) while also exhibiting outstanding antibacterial properties against microbes. Furthermore, despite the difficulty of washing natural plant-based antimicrobial finishes, they are generally approved antimicrobial agents for textile finishing due to their environmental friendly property. Plant-based nanoparticle antimicrobial compounds are increasingly being used in a variety of industries, owing to their superior features and protection against infections when compared to conventional antimicrobial agents (Afraz, 2019).

CONCLUSION

The aesthetic properties like smoothness and surface appearance of antimicrobial finish had a large positive effect on 100% polyester. The Aesthetic property of polyester fabric was increased after applying antimicrobial finish. The antimicrobial finish of the three experimental groups, plant leaves have a substantial impact on the stiffness (warp + weft). Antibacterial finishes create a coating on treated fabric, which makes it stiffer than untreated cloth. This study showed that developed antibacterial fabric is suitable doctors, premature babies, athletic were industry even for the general public. Results showed that using an antimicrobial finish made from the leaves of *A. indica*, *B. monosperma*, and *L. chinensis* reduced the amount of bacteria on polyester fabric by 100% when compared to the control group. The result shows that antimicrobial finish increased the Stiffness while smoothness appearance was decreased in case of *A. indica* and *B. monosperma* and increased in case of *L. chinensis*.

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