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Research Article

Effect of Antimicrobial Finish on Mechanical Property of Cotton Fabric

Shama Sadaf[1]*, Komal Hassan[1], Ayesha Saeed[1] and Zeeshan Ahmad[2]

[1]Department of Home Economics, Lahore College for Women University, Lahore, Pakistan; [2]School of Science and Technology, University of Management and Technology, Lahore, Pakistan.

Abstract | The study was aimed to applying eco-friendly antimicrobial finish on cotton fabric and checked mechanical property by pre and post-test and durability of this finish was checked up to 25 washes. The eco-friendly antimicrobial finish was extracted from leaves of *Azadirachata indica*, *Butea monosperma* and *Litchi chinensis* plants and applied on 100% cotton. Before and after applying antimicrobial finish mechanical property was checked. The antimicrobial finish was applied by pad dry cure method and finish was fixed by using of poly urethane binder. The presence of microorganisms was checked by ASTEM E2149 shake flask method before and after applying antimicrobial finish and after successive 25 washes. The results were analyzed through MANOVA. The fabric properties were checked by using ISO standard test methods. The fabric which was treated with *A. indica* showed 100% reduction on all samples after 22 hours, but after six days only one colony of microorganism was appeared on treated fabric, while nine colonies was observed on untreated cotton sample The cotton fabric treated with *B. monosperma* and *L. chinensis* exhibited 100% reduction after 22 hours and even after six days interval. In case of mechanical properties (Tensile strength, Tear strength) antimicrobial finish had made positive effect on cotton. The antimicrobial finish lasted up to 25 washes. The study suggested that antimicrobial fabric is suitable to provide protection cover for medical industry, paramedical staff, sports wears, home furnishing as well as common people.

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***Correspondence** | Shama Sadaf, Department of Home Economics, Lahore College for Women University, Lahore, Pakistan; **Email:** sadaf.shama@gmail.com
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1. Introduction

Textiles belongs to natural polymers having a plant based (vegetable) origin. It has been originated and used by humans since centuries with the aim of covering (bodies) and protection (temperature, dust, sunlight, wind etc.). Apparel has also been an important aspect of human life and it has become necessity of life with the development of advanced technologies. Medical textiles are a very promising sector among technical textiles, which is directly related to the health and well-being of mankind. It comprises of textiles used by doctors, nurses and paramedical staff, wards and pre and post-operative tasks (El-Shafei *et al*., 2018).

Bacterial or other pathogenic microbes, either harmful or beneficial to humans, are present in our surroundings everywhere. Different bacterial species are present in skin, nasal cavities, gut and other body parts of human body (Qian *et al*., 2004; Sheikh *et al*., 2019). Pathogenic bacterial species such as Escherichia coli *(E. coli)* and Staphylococcus aureus *(S. aureus)* are mainly present on textiles and clothing (Kang *et al*., 2016). Diseases causing nature of certain microbial species present in the environment has compelled the researchers to introduce microbe resilient finishes for clothing and textiles. The center of attention of today's era is to develop a sustainable, disease-free and hygienic living conditions for the betterment of mankind (Herrera *et al*., 2006; Hudec *et al*., 2007; Ibrahim *et al*., 2006).

Textiles have always played a significant role in the development of human culture by being at the forefront of technological and artistic development. The protective aspects of textiles have provided the most textile ground for innovative development. Hygiene has gained importance in recent years. Consumers are now increasingly conscious of a hygienic lifestyle and there is a need and expectation for a wide range of textile products with antimicrobial properties. Microorganism growth is also another factor that results in the development of an antimicrobial treatment (Chung *et al*., 2022).

Microbes are the smallest creatures that we cannot see with the naked eye. Bacteria are single-celled organisms that grow very quickly in heat and moisture. Some specific types of bacteria cause infection. Dust mites inhabit home textiles such as blankets, bedding, pillows, mattresses and carpets. Mites feed on human skin cells and the released waste products can cause allergic reactions and respiratory disorders (Patel *et al*., 2015).

Textile finishing is a term for a whole range of mechanical and chemical processes that are applied to textiles after their manufacture to ensure the required qualities and increase their marketability. Textile finishing does not involve dyeing, but it can make fabrics more welcoming to dyes. A textile finish is used to achieve desired effects and may have aesthetic or functional benefits (Kumar *et al*., 2017).

Cotton fibers are natural hollow fibers; they are soft, cooling, known as breathable fibers and absorbent. Cotton fibers can hold 24-27 times their own weight in water. They are strong, absorb dyes and resist wear from abrasion and high temperatures. Cotton is, in a word, comfortable (Ahmed, 2020).

An abundantly available natural organic fiber is cotton. Cotton is easily attacked by microorganisms. Microbial development of the textile causes loss of strength and elasticity. Azadirachta Indica leaf extract kills bacteria by inhibiting their growth. One of the more powerful benefits of Azadirachta Indica extract is its effect on the skin. Leather is usually covered with fabrics and made of cotton fabric (Zaghloul *et al*., 2017; Purwar *et al*., 2014).

Butea monosperma is used to treat microbial and fungal infections in folk medicine. Butea monosperma also known as flame of the forest. *B. monosperma* has been reported in the literature to have many medicinal properties. It is used as an antibacterial and antifungal agent. The leaves. extract of *Butea monosperma* was *used* as an eco-friendly antimicrobial finish (Shahid-ul-Islam *et al*., 2019).

The study was aimed to applying eco-friendly antimicrobial finish on cotton fabric and checked mechanical property by pre and post-test and durability of this finish was checked up to 25 washes. In mechanical property Tensile and tearing strength of cotton fabric was checked. The mechanical property plays an important role as it is an induced property that may helpful if a fabric ruptures take place.

2. Materials and Methods

In this look at antimicrobial finish become extracted from three plant life leaves i.e. A. Indica, *B. Monosperma* and *L. chinensis* and implemented on four fabrics i.e. One hundred% cotton. Flowers' extractions had been manipulated via making concentration tiers, in one degree pure plant extraction became implemented and in different level 50% concentration answer turned into used. Exclusive gadgets inclusive of Autoclave, warm Air Oven have been used to test microorganisms' presence. Titan tensile power tester and Elematear tearing power tester were used for mechanical residences to impart finish on fabrics, pad dry treatment system become used.

The material samples have been reducing, handled with antimicrobial end and then examined to manipulate their effectiveness as antimicrobial fabric. Antimicrobial marketers had been extracted from leaves of *A. indica, B. monosperma* and *L. chinensis*. Extractions of antimicrobial marketers from flowers have been executed in laboratory of Botany department, government university college, Lahore.

Sample of fabric 100 % cotton was taken from fabric trader of Faisalabad. Sample size was 20 yards for each fabric which depended upon the checking fabric properties and tests. Unfinished fabrics were taken and these were bleached in NTU. After purchasing the fabric, 100% cotton was first desized. In desizing enzyme Bactasal HTN was used in ratio of 1g/litre. The pH was 5-6 and temperature was 60-70 degree centigrade. 100% cotton fabric was dipped in solution for 45 minutes. Scouring was done by using NaOH. The cotton was treated for 1 hour. The process of extraction can be seen in the following flowchart Figure 1.

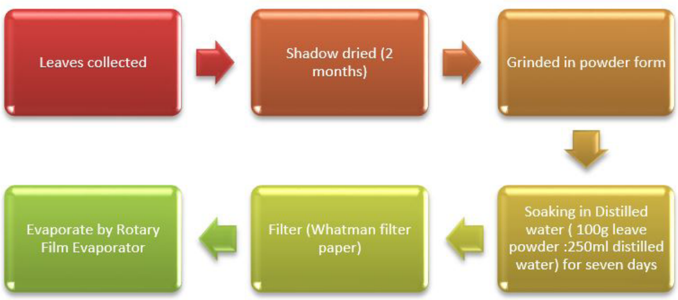

Figure 1: General flow diagram showing solvent extraction.

The ratio of grinded leaves and distilled water was 100 g/250 ml. This process was repeated for *B. monosperma* and *L. chinensis*. Leave this soaked material for 7 days and stirred it twice a day. After that it was filtered by using muslin cloth then filtered again by using Whatman filter paper. The filtered extracts of *A. indica* (Neem), *B. monosperma* and *L. chinensis* were concentrated by a rotary film evaporator.

The three *indica* (A), *B. monosperma* (B) and *L. chinensis* (L). So there were four samples from cotton fabric. On untreated cotton samples no finish was applied. On sample A *A. indica* antimicrobial finish was applied, on sample B *B. monosperma* leaves extract antimicrobial finish was applied and on sample L *L. chinensis* leaves extract antimicrobial finish was applied, respectively. The untreated cotton sample was the control group and the cotton samples treated with *A. indica*, *B. monosperma* and *L. chinensis* leaves extract antimicrobial finish were meter fabric sample was taken as length and twelve inch as width from cotton fabric; label untreated (un), *A.* experimental group. The antimicrobial finish was applied by using the pad dry cure machine in NTU. On pad dry cure machine (process) drying was done at 120°C temperatures for 2 minutes and curing was done 150°C temperatures for 3 minutes.

After applying this concentration antimicrobial finish, Mechanical properties (Tensile strength, Tear strength) properties were checked in NTU on all four fabric samples.

2.1 Binder application

One kg Poly Urethane Binder was taken from CHT. The ASTEM E2149 Shake Flask Method was used and result shown that binder has no antimicrobial property.

2.2 Mechanical properties

2.2.1 Tearing strength

The tearing strength of the fabrics was measured with a falling-pendulum type device. Tear strength as a mechanical property was measured using standard test methods D 1424–07. This test process covers the purpose of the force required to propagate a single tear when cutting the fabric and using Elmendorf machine. A piece of fabric was cut in the middle and the sample was held between two clamps and the sample was torn through the static space. Tear resistance was partially accounted for on the scale of the instrument and was calculated from this value and the pendulum capability. Five samples were taken in the warp direction and five samples in the weft direction. Find the average of these five values.

2.2.2 Tensile strength of fabrics

Tensile strength as a mechanical property was measured using the European standard EN ISO 13934-1:1999 has the status of British standard ICS 59.080.30. This method was used to determine the maximum required force and elongation at maximum force using the strip method.

Cut five fabric samples in the warp direction and five in the weft direction. Place the specimen in the tensile testing machine between the two clamps and apply the force in the opposite direction. At the maximum force, the maximum elongation occurred, after which the sample rupture was recorded. All samples should be conducted in a standard atmosphere with a relative humidity of 65 ± 2% at 21 ± 1 °C (70 ± 2 °F). When conducting the experiment, there should be no oil, water, grease and so on on the samples.

2.3 Data analysis and interpretation

Figure 2a, b, c show that after 22 hours there were no microorganisms' growth on untreated fabric. The fabric which was treated with *A. indica*, *B. monosperma* and L. chinensis all show zero reading after 22 hours. At x-axis there are readings of fabric with 3 intervals 1, 2 and 3. At y-axis there is presence of microorganism's with 2 intervals 0 and one zero means no microorganism's while at level 1 microorganism's are present. First figure show the reading of *A. indica*, second figure shows the reading of *B. monosperma* while last figure show the reading of *L. chinensis*.

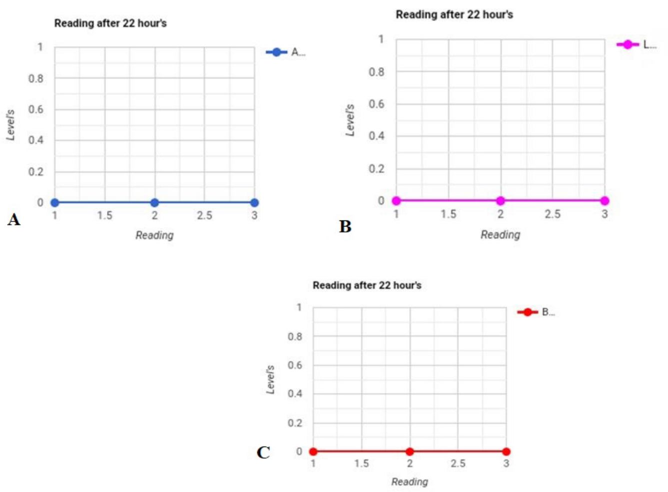

Figure 2: Quantitative analysis test results of treated cotton samples *A. indica* (A); *L. chinensis* (B) *B. monosperma* (C) after 22 hours.

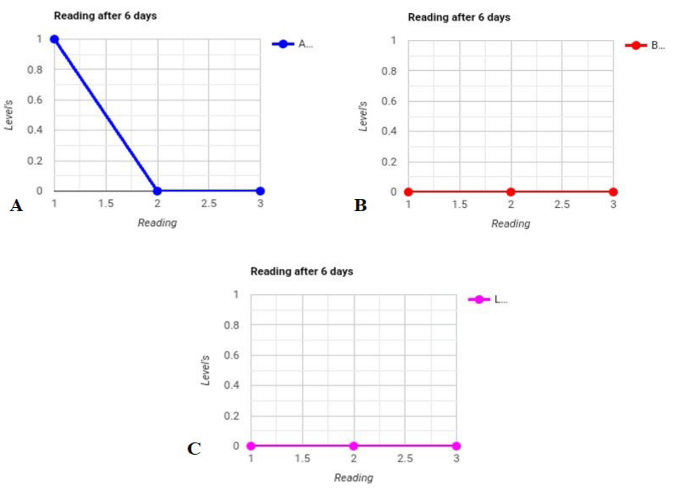

Figure 3: Quantitative analysis test results of treated Cotton treated with *A. indica* (A); *L. chinensis* (B) *L. chinensis* after 6 days.

Figure 3a, b, c show that at x-axis there are readings of fabric with 3 intervals 1, 2 and 3. At y-axis there is presence of microorganism's with 2 intervals 0 and one zero means no microorganism's while at level 1 microorganism's are present. First figure show the reading of *A. indica*, second figure shows the reading of *B. monosperma* while last figure show the reading of *L. chinensis*. After six days only one colony of microorganism was appeared, while on untreated cotton sample nine colonies of microorganisms' presences was found. The reason was that on untreated fabric no antimicrobial treatment was given that's why microbes colony was more in number after six days while on treated fabric only on one sample out of 18 samples microorganisms presence was observed due to effectiveness of antimicrobial finish.

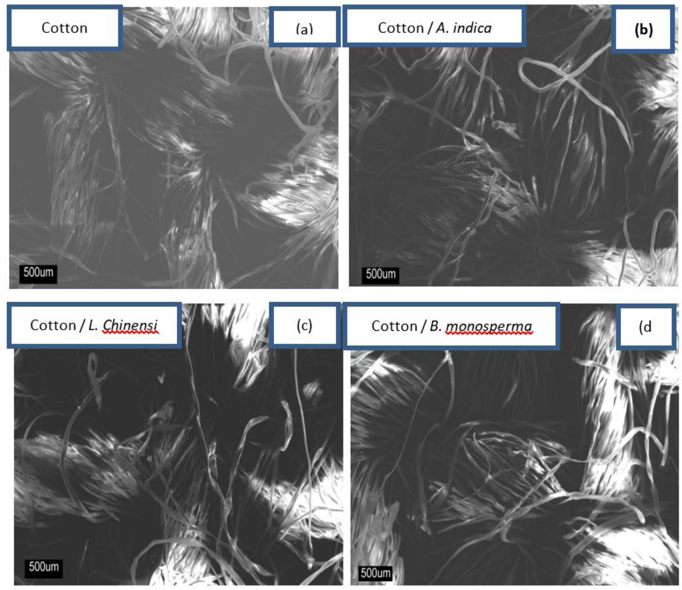

Figure 4: SEM micrographs of untreated and treated cotton fabric.

In Figure 4 SEM micrograph clears the treatment of *Azadhrachta indica (A. Indica), Litchi chinensis (L. chinensis)*, and *Butea monosperma (B. monosperma)* on Cotton fabrics. Figure 4 dipicts the effect of treatment of extract on cotton fabric. Figure 4a is the SEM image of untreated cotton fabric, Figure 4b is *A. indica*, Figure 4c is *L. chinensis*, and Figure 4d is *B. monosperma* antimicrobial finish treated cotton fabric. The treated cotton fabric treated shows presence of finish as compare to untreated fabric.

2.4 Effect of antimicrobial finish on mechanical property of cotton fabric

A summary of the fabric tear and tensile strength results is given in Table 1. These results are discussed in the following sections.

Table 1: Multivariate and univariate analysis: Effect of antimicrobial finish on tensile and tear strength of cotton fabric.

	Plant		
	F	P	η^2
Multivariate	5.74	.006	.939
Univariate			
Tensile Warp	33.98	.000	.93
Tensile Weft	.78	.539	.23
Tensile Warp + Weft	6.37	.005	.54
Tear Warp	60.92	.000	.96
Tear Weft	6.63	.023	.68
Tear Warp + Weft	13.19	.000	.712

Table 1 shows the results of pillai's (.006) indicatess that there was significant difference of antimicrobial finish on tensile and tear strength of cotton fabric and its effect size was large (η^2=.939).

ANOVA was applied to find the significance difference of *A. indica, B. monosperma, L. chinensis* and control group plants extract on tensile warp, weft and tear strength warp, and weft of cotton fabric. The result of F test indicatess that there was significance difference of Antimicrobial finish on tensile strength warp (.000) on cotton fabric and the effect size was large (η^2=.93), while there was no significance difference of Antimicrobial finish on tensile strength weft of cotton fabric. The result of F test indicatess that there was significance difference of Antimicrobial finish on tensile strength warp +weft (.005) on cotton fabric and the effect size was large (η^2=.54).

The result of F test indicates that there was significance difference of Antimicrobial finish on tear strength wrap (.000) on cotton fabric and the effect size was large (η^2=.96), F test result of tear strength weft was (.023) and its effect size was large (.68). The result of F test indicatess that there was significance difference of Antimicrobial finish on tear strength wrap (.000) on cotton fabric and the effect size was large (η^2=.712)

Table 2 shows that *A. indica*, *B. monosperma* and *L. chinensis* plant extract have effect on tensile strength warp and tear strength warp, weft of cotton fabric as compare to control group. The mean score of tensile strength warp of control group (Mean=27.20, SD= 3.21) was less as compare to mean score *A. indica* (Mean=38.23, SD=2.51) and *B. monosperma* (Mean=37.07, SD=1.18) and *L. chinensis* was (Mean= 32.00, SD=4.01). The mean score of tensile strength warp+ weft of control group (Mean=25.23, SD= 3.15) was less as compare to mean score *A. indica* (Mean=30.80, SD=2.17) and *B. monosperma* (Mean=29.80, SD=1.44).

The antimicrobial finish increased the tensile strength of treated as compare to untreated fabric. The reason was that antimicrobial finish makes a coating on fabric which cause increase the tensile strength of treated fabric.

The mean score of tear strength warp of control group (Mean=3824.00, SD=104.31) was more as compare to *A. indica* (Mean=3512.00, SD=121.33), *B. monosperma* (Mean=3384.00, SD=143.11) and *L. chinensis* was (Mean= 3384.00, SD=104.31). The mean score of tear strength weft of control group (Mean=2728.00, SD=165.89) was less as compare to *A. indica* (Mean=2424.00, SD=210.90), *B. monosperma* (Mean=2328.00, SD=91.21) and *L. chinensis* was (Mean= 2300.00, SD=56.57). The mean score of tear strength warp +weft of control group (Mean=3276.00, SD=131.45) was more as compare to *A. indica* (Mean=2968.00, SD=157.86), *B. monosperma* (Mean=2856.00, SD=116.10) and *L. chinensis* was (Mean= 2842.00, SD=77.59). The antimicrobial finish increase the tensile strength of treated as compare to untreated fabric. The reason was that antimicrobial finish makes a coating on fabric which cause increase the tensile strength of treated fabric.

Figure 5: *Untreated and treated fabrics after successive washes.*

Figure 5 shows the readings of microorganism's presence of 100% cotton fabric after five washes interval. In table zero mean no colony of microorganisms while

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one mean presence of microorganisms. On 100% untreated (blue colour) cotton fabric microorganism's presence was shown after 10 washes, 20 washes and 25 washes. The treated fabric (red colour) continuously shows zero reading on all intervals which mean there is no microbial growth up to 25washes. While untreated fabric showed microorganisms presence at at two intervals i.e. 10 washes and 20 washes.

In a study cotton fabrics were treated with *Azadirachata indica* for the purpose of imparting a durable antimicrobial finish. As the result of which it was found that there was change in tensile strength occur the fabric treated with *Azadirachata indica* has increased tensile strength then non treated fabric and the mean of tensile strength is 34.03 (Raymond *et al*., 2011). In the present research it is found that the antimicrobial finish increased the tensile strength of treated fabric as compare to untreated fabric, and the mean value is 38.23. So the result of Bang study B support the result of current study (Bang *et al*., 2007).

In another study Butea monosperma as Antimicrobial finish was applied on cotton fabric and durability was checked after 5 washes interval. The tear strength was measured by Falling Pendulum Apparatus. The result showed the cotton fabric treated with antimicrobial finish having improved tearing strength then untreated fabric and the mean value is 3394.01 (Romero *et al*., 2017). In the current study tearing strength of fabric was measured by Falling-Pendulum Apparatus. The tear strength as mechanical property was measured by using D 1424–07 standard test methods. The result showed that treated fabric has improved tear strength after applying antimicrobial finish a and th mean value of this test is 3384.00 which is also supported by previous study resut.

Burkitbay conducted a study in 2014, in result of this study F test indicate that antimicrobial finish influence the effect size of warp and weft of cotton fabric tear strength. As the result of which the warp effect size was large (η^2= .95) and the weft size was large

Table 2: *Effect of Antimicrobial finish on tensile warp and tear warp, weft of cotton fabric.*

	Plant Name	Mean Difference (I-J)	Std. Error	Sig.[b]
Tensile Strength Warp	Control vs *A. indica*	-11.379*	1.332	.000
	Control vs *B. monosperma*	-11.191*	1.332	.000
	Control vs *L. chinensis*	-4.796*	1.332	.007
Tear Strength Warp	Control vs *A. indica*	333.333*	38.873	.000
	Control vs *B. monosperma*	466.667*	38.873	.000
	Control vs *L. chinensis*	440.000*	38.873	.000
Tear Strength Weft	Control vs *A. indica*	306.667*	101.544	.017
	Control vs *B. monosperma*	360.000*	101.544	.008
	Control vs *L. chinensis*	346.667*	101.544	.009
Effect of Antimicrobial finish on tensile and tear of cotton fabric				
Tensile Strength (Warp+Weft)	Control vs *A. indica*	-5.573*	1.505	.002
	Control vs *B. monosperma*	-4.576*	1.505	.008
	Control vs *L. chinensis*	-1.079	1.505	.484
Tear Strength (Warp+Weft)	Control vs *A. indica*	308.000*	78.549	.001
	Control vs *B. monosperma*	420.000*	78.549	.000
	Control vs *L. chinensis*	434.000*	78.549	.000

	Control group	***A. indica***	***B. monosperma***	***L. chinensis***	Control group	***A. indica***	***B. monosperma***	***L. chinensis***
Tensile Warp	27.20	3.21	38.23	2.51	37.07	1.18	32.00	4.01
Tensile Weft	23.25	3.53	23.37	1.91	22.54	1.70	20.48	1.23
Tensile Warp + Weft	25.23	3.15	30.80	2.17	29.80	1.44	26.31	2.44
Tear Warp	3824.00	104.31	3512.00	121.33	3384.00	143.11	3384.00	104.31
Tear Weft	2728.00	165.89	2424.00	210.90	2328.00	91.21	2300.00	56.57
Tear Warp + Weft	3276.00	131.45	2968.00	157.86	2856.00	116.10	2842.00	77.59

(η^2=.711) so there was significant difference before and after applying the antimicrobial finish (Burkitbay, 2014). In current study, The result of F test indicates that there was significance difference of Antimicrobial finish on tear strength wrap (.000) on cotton fabric and the effect size was large (η^2=.96), F test result of tear strength weft was (.023) and its effect size was large (.68). The result of F test indicates that there was significance difference of Antimicrobial finish on tear strength wrap (.000) on cotton fabric and the effect size was large (η^2=.712). So the result of previous study support support the result of current study.

In previous research, tearing strength and tensile strength both was measured on cotton fabric with antimicrobial finish. Both tests were applied on cotton fabric after different washes interval using 1993 AATCC standard reference. The fabric was washed according to test standard method. It was determined that antimicrobial finish improved the both tensile strength and tearing strength of cotton fabric (Bhatt *et al*., 2015). In current study the cotton fabric was washed by using 1993 AATCC standard reference method. After washing with the mechanical properties (tearing strength, tensile strength) was measured and it was noted that both properties were improved, so the result of Tandel study support the result of current study.

In previous research, the tensile strength of antimicrobial-treated cotton fabric was measured according to European ENISO 13934-1:1999, which specifies the maximum required strength and elongation. And it was found that the tensile strength of the treated fabric was improved as compared to the untreated fabric. Antimicrobial treatment improved the mechanical properties of cotton fabric (Hakraborty *et al*., 2015). Tensile strength as a mechanical property was measured using the European standard EN ISO 13934-1:1999 has the status of British standard ICS 59.080.30. This method was used to determine the maximum required force and elongation at maximum force using the tape method, and using this test it was measured that the tensile strength of the antimicrobial treated fabric was improved which also support the result of current study.

Novelty Statement

In this study first time *Butea Monosperma* and Litchi Chinensis leave's extract was used for preparing the antimicrobial finish and applied on cotton fabric.

Author's Contribution

SS gave the concept of idea, design of work, and interpretation of data. KH performed the drafting of the manuscript. ZA give revisions to the manuscript and interpreted data. AS also performed the interpretation of data and give revision of the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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