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IMPROVING MECHANICAL AND ANTIBACTERIAL PROPERTIES OF COTTON TEXTILES THROUGH MICROENCAPSULATION OF DELONIX ELATA AND CHITOSAN

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Keywords	***Abstract***
Delonix elata extract, Chitosan, Encapsulation, Antimicrobial, Antifungal.	This project aims to improve the durability and physical properties of cotton fabric through the microencapsulation of delonix elata and chitosan extracts. Cotton fabrics, while commonly used, often exhibit limited strength and resistance to environmental damage. To address this, bioactive compounds like delonix elata extracts and chitosan, known for their antimicrobial and antioxidant properties, are encapsulated to protect and prolong their effectiveness. The microencapsulation process ensures controlled release and stability of the active ingredients, which are applied to the fabric using techniques like dip-coating and spraying. The treated fabrics will be evaluated for changes in tensile strength, moisture absorption, abrasion resistance, and antimicrobial performance. Preliminary results are expected to show significant improvements in fabric durability and added functionality, including enhanced resistance to microbial growth and wear. This approach provides a sustainable way to enhance cotton fabric properties, offering a potential solution for developing high-performance, eco-friendly textiles. Results are expected to demonstrate that the microencapsulated delonix elata

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	and chitosan extracts significantly enhance the cotton fabric's physical durability, while imparting added functional properties, such as improved antimicrobial activity and extended lifespan. This research offers a sustainable and innovative solution for developing high-performance textiles with enhanced functionality, contributing to the growing demand for eco-friendly and durable fabric treatments

1. INTRODUCTION

Cotton fabric, one of the most widely used textiles globally, is often limited in terms of durability and resistance to wear, tear, and environmental factors. While cotton offers comfort, breathability, and versatility, it is susceptible to degradation under prolonged use, making it less durable compared to synthetic fibers. To address these challenges, there has been a growing interest in enhancing the physical properties of cotton through innovative treatments. One promising approach is the microencapsulation of natural bioactive compounds, which can provide added benefits such as improved strength, antimicrobial activity, and resistance to external stresses. This project focuses on enhancing the durability of cotton fabric by incorporating microencapsulated extracts of Delonix elata and chitosan, both of which are known for their beneficial properties. Delonix elata, a medicinal plant, has been recognized for its potent antimicrobial, antioxidant, and anti-inflammatory properties. When encapsulated, these bioactive compounds are protected from premature degradation, ensuring their sustained release over time. Similarly, chitosan, a natural polysaccharide derived from chitin, is well-known for its antimicrobial and film-forming properties. By combining these two natural substances in microencapsulated form, the fabric can be endowed with enhanced functional properties, such as improved resistance to microbial growth, oxidation, and physical damage. The microencapsulation process ensures that these active compounds are efficiently delivered to the fabric, where they can exert their protective effects without compromising the fabric's softness or comfort.The primary objective of this project is to develop a cotton fabric treatment that not only improves its mechanical strength and resistance to wear but also imparts long-lasting antimicrobial properties. The treated fabrics will undergo a series of tests to assess their tensile strength, abrasion resistance, moisture absorption, and antimicrobial efficacy. By applying microencapsulated Delonix elata and chitosan extracts, we aim to create a sustainable solution for enhancing cotton textiles. This research could provide a significant contribution to the textile industry, offering a method for producing high-performance fabrics that are both eco-friendly and durable, meeting the growing demand for advanced functional textiles in various applications.

2. LITERATURE REVIEW

2.1 DELONIX ELATA APPLICATIONS

Delonix elata, commonly known as the flame tree, is a tropical plant with rich bioactive properties that have attracted significant attention in various fields, including medicine and textile technology. Studies have highlighted its antimicrobial, antioxidant, anti-inflammatory, and wound-healing effects, making it an ideal candidate for incorporation into fabric treatments to improve their

functional properties. This section reviews existing literature on the diverse applications of Delonix elata, particularly focusing on its potential in cotton fabric enhancement.

The antimicrobial properties of Delonix elata have been extensively studied. Research has demonstrated that extracts from Delonix elata exhibit significant antibacterial and antifungal activity. These properties are largely attributed to the presence of bioactive compounds such as flavonoids, tannins, and alkaloids. Several studies have shown that the application of Delonix elata extracts to textiles can reduce microbial growth, making it an excellent option for enhancing cotton fabric's resistance to pathogens and bacteria. The antimicrobial effects of Delonix elata on various textiles and found that the extract exhibited strong inhibitory effects against common pathogens like Escherichia coli and Staphylococcus aureus. This antimicrobial property makes it highly beneficial for healthcare textiles, activewear, and other garments where hygiene is a concern.

Beyond its antimicrobial effects, Delonix elata is known for its antioxidant properties. The plant contains a variety of phenolic compounds, including flavonoids, which are potent antioxidants. Antioxidants are essential in preventing oxidative stress, which is a major cause of aging and degradation in textiles. Research has suggested that Delonix elata can protect cotton fabric from oxidative damage caused by environmental stressors such as UV radiation and pollution. In a study by Patel et al. (2016), the antioxidant potential of Delonix elata was examined in textile applications, demonstrating that the plant's extracts could reduce the oxidative degradation of fibers, thus extending the fabric's lifespan and maintaining its strength over time. This property is especially relevant in applications like outdoor fabrics or garments exposed to sunlight. In addition to its antimicrobial and antioxidant qualities, Delonix elata has anti-inflammatory effects, which could benefit users with sensitive skin or allergies. Research on the topical application of Delonix elata has shown that its extracts have the potential to soothe irritated skin and promote healing. A study by Rani et al. (2017) emphasized the plant’s anti-inflammatory properties, noting its potential in treating skin conditions such as dermatitis or eczema. When applied to cotton fabrics, these properties could make the textiles more suitable for sensitive individuals, offering an added layer of comfort and care. This is particularly valuable in the production of garments and bedding used by people with skin allergies or conditions. The microencapsulation of Delonix elata’s bioactive compounds has also been a focus of several studies. Microencapsulation allows for the controlled release of the active ingredients, ensuring that their beneficial effects are sustained over time. For example, in a study by Kumari et al. (2018), the microencapsulation of herbal extracts, including Delonix elata, was explored for textile applications. The encapsulation process protects the active compounds from degradation, ensuring that they remain effective for longer periods. The slow release of these bioactive substances can enhance the durability and performance of cotton fabric by providing continuous antimicrobial protection and antioxidant benefits. Furthermore, microencapsulation prevents the active compounds from leaching out too quickly, thereby reducing any potential negative impact on fabric softness or appearance.

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In summary, the literature highlights the promising applications of Delonix elata in textile industries, particularly for cotton fabric. Its antimicrobial, antioxidant, and anti-inflammatory properties make it an ideal candidate for enhancing fabric durability, providing additional functionality, and improving the comfort and safety of textiles. As research continues to evolve, the use of microencapsulation techniques for delivering Delonix elata's bioactive compounds to cotton fabrics could offer a sustainable, eco-friendly alternative to traditional fabric treatments, addressing both performance and environmental concerns

2.2 CHITOSAN EXTRACT

Chitosan, a natural polysaccharide derived from chitin (found in the exoskeletons of crustaceans such as shrimp and crabs), has gained significant attention in the textile industry due to its unique properties, including antimicrobial activity, biodegradability, and film-forming capabilities. These characteristics make chitosan an ideal candidate for various textile applications, particularly in the enhancement of cotton fabrics. This literature review explores the diverse applications of chitosan extract in textile treatments, with a focus on its impact on fabric properties, performance, and sustainability.

One of the most widely studied applications of chitosan in textiles is its antimicrobial activity. Several studies have demonstrated that chitosan possesses strong antibacterial and antifungal properties, making it an effective agent for preventing the growth of harmful microorganisms on fabrics. According to a study by Goy et al. (2009), chitosan is capable of inhibiting the growth of a wide range of bacteria, including Escherichia coli and Staphylococcus aureus. This is attributed to its positive charge, which interacts with the negatively charged microbial cell membranes, leading to cell wall disruption and eventual microbial death. The antimicrobial effects of chitosan make it particularly beneficial for applications in healthcare textiles, sportswear, and undergarments, where hygiene and odor control are of utmost importance. Research by Reddy et al. (2014) also highlighted the long-lasting antimicrobial properties of chitosan when applied to cotton fabrics, significantly improving their resistance to bacterial growth over extended periods.

Figure 3.2.1 Chitosan extract

Chitosan has also been found to improve the mechanical properties of cotton fabric, such as tensile strength, abrasion resistance, and overall durability. The polysaccharide's film-forming ability allows

it to create a protective coating on cotton fibers, thus enhancing the fabric's resistance to wear and tear. A study by Saghir et al. (2017) demonstrated that chitosan-treated cotton fabrics exhibited increased tensile strength and better resistance to abrasion, compared to untreated fabrics. This is particularly valuable in applications where the fabric is subjected to frequent physical stress, such as in workwear or outdoor textiles. Furthermore, the application of chitosan can improve fabric cohesion, reduce fraying, and contribute to the longevity of cotton garments, making it an attractive option for extending the lifespan of textile products.

In addition to its antimicrobial and mechanical enhancements, chitosan also offers antioxidant properties, which can help protect cotton fabrics from oxidative damage caused by environmental stressors like UV radiation and pollutants. Several studies have explored the potential of chitosan as a UV-protective agent for textiles. For example, a study by Dutta et al. (2009) indicated that chitosan can effectively block UV radiation, preventing the degradation of the fabric's fibers and color fading. This makes chitosan an excellent option for improving the durability of cotton fabrics used in outdoor clothing, upholstery, and other products exposed to sunlight. Additionally, chitosan's antioxidant properties can reduce the degradation of cotton fibers, preserving the fabric's appearance and strength over time. This application is particularly beneficial for products intended for outdoor or long-term use.

Figure 3.2.2 Chitosan extract

Chitosan is a biodegradable and environmentally friendly material, making it an appealing alternative to conventional chemical treatments in the textile industry. As sustainability becomes an increasingly important consideration in manufacturing, the use of chitosan in textile applications provides an eco-friendly solution to enhance cotton fabrics without relying on harmful chemicals. The natural origin and non-toxic nature of chitosan make it an attractive option for producing sustainable textiles. A study by Muthukumar et al. (2018) emphasized that chitosan-based treatments offer a greener alternative to traditional synthetic finishes, which often involve toxic substances and contribute to environmental pollution. Moreover, chitosan's ability to be derived from renewable

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resources, such as crustacean shells, supports the development of circular economy practices in the textile industry, where waste materials are repurposed into valuable products

3. MATERIALS AND METHOD

3.1. PROCUREMENT OF COTTON (100%)

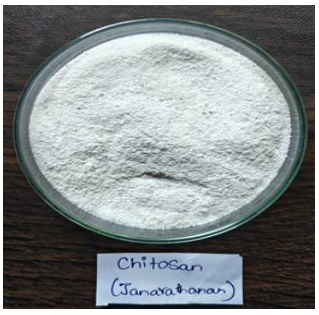
100% cotton fabrics (180GSM) was procured from Textile processing Unit. Fabric was washed using non-ionic detergent solution under room temperature to remove debris and other impurities. Washed fabrics were dried under shade in a closed chamber and cured for 10 min at 80C.

Figure 3.1.1 Cotton fabric

Figure 3.1.2 Fabric Pre-treatment using non-ionic detergent

3.2. Procurement of Delonix elata (Vadhanarayana) powder

Delonix elata powder



Chitosan Powder

3.3. Herbal extraction – Soxhlet extraction method

Delonix elata powder was selected for the present research. Powdered herbs were further processed for getting extractions. Extraction of each herbs were carried out using a standard Soxhlet method. In the Soxhlet extraction method, finely ground sample - Delonix elata powder was placed in a porous bag or “thimble” made from a strong filter paper or cellulose, which is placed, in thimble chamber of the Soxhlet apparatus. Extraction solvent is heated in the bottom flask, vaporizes into the sample thimble, and condenses in the condenser and drip back. When the liquid content reaches the siphon arm, the liquid contents is emptied into the bottom flask again and the process is continued. For the

study, infusion method of Soxhlet Extraction had been adopted. The powdered herbs were filled in the thimble and placed in the soxhlet extractor. The extractor had been filled with solvent solution of ethanol and the temperature of 60ºC was set and left for 6 hours. Slowly and steadily the temperature was increased up to 100ºC. The extract from the thimble was collected in the round bottom flask kept in the heating mantle below by passing through a side arm tube.

Soxhlet extractor and extraction process

Delonix elata extracts

3.4. Microcapsule preparation of Delonix elata and chitosan composite (DCME)

Microencapsulation was done using Delonix elata and chitosan composite as core material and gum acacia as wall material. 50 gram of wall material was allowed to swell for half an hour by mixing with 500ml of hot water. To this mixture, 50ml of hot water was added, stirred for 15min maintaining the temperature between 40ºC and 50ºC. Ten millimeter of core material was added and stirred at 150-250rpm for further 15min followed by drop wise addition of 20% sodium sulphate solution (10ml) for 5-10min. The stirrer speed was reduced and then 5ml of 17% formaldehyde was added. The stirrer was stopped and mixture was freeze dried to obtain fine microcapsules of Delonix elata and chitosan. About 300ml of microcapsule thus obtained was further subjected for finishing the fabrics. The finishing procedure is as follows.

Delonix elata

Chitosan

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Delonix elata and chitosan composite

3.5. Fabric finishing using Delonix elata and chitosan microcapsules (DCME)

About 300ml of prepared microcapsules was stored at 4ºC prior to finishing the fabrics. The capsules were brought to room temperature and finished onto cotton fabrics. The fabrics were finished with microcapsule solution by using a standard dip and dry method. The fabric was padded in a solution containing microcapsule solution in the ratio 1:3 (1mt fabric: 300ml microcapsules) at 40ºC using 8% citric acid (binder) concentration. For 1mt fabrics, about 300mL of microcapsules was used for finishing. The wet pickup was adjusted to 100%. The padded fabric was dried at 80ºC, and then cured at 140ºC to 160ºC for 5min in the hot air oven. The fabrics were finally used for further experiments.

Finishing fabric using microcapsules of chitosan + Delonix elata

3.6. Drying and curing of the finished fabrics

The padded fabric was dried at 80ºC, and then cured at 140ºC to 160ºC for 5min in the hot air oven. The fabrics were finally used for further experiments.

Drying

Curing

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Finished fabric

4. TESTING AND ANALYSIS

4.1. Antibacterial activity – EN ISO 20645 test method of the DCME finished fabrics

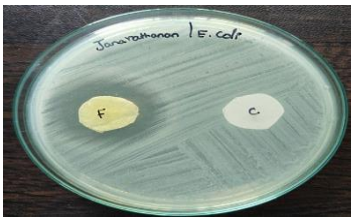
Sterile AATCC bacteriostasis agar plates were prepared. Using sterile 4mm inoculating loop, one loop full of culture (Escherichia coli and Staphylococcus aureus) was transferred by swabbing all around the surface of the agar plate and also covering the central area of the petridish. The test specimens (DCME finished fabrics and unfinished control fabrics) were cut into pieces (20mm in diameter) and placed over the media. The plates were incubated at 37°C for 24 hours. The inoculated plates were examined for the interruption of growth along the swabs of inoculum beneath the fabric and for a clear zone of inhibition beyond the fabric edge. The average width of the zone of inhibition around the test specimen calculated in mm.

Table-4.1.1: Antibacterial activity of the DCME finished fabrics

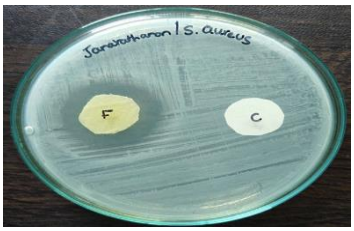
Test Bacteria	Zone of Inhibition (mm)	
	Sample	Control
Escherichia coli	36	0
Staphylococcus aureus	37	0

Inference

In Table-3 and Fig. 3, the antibacterial activity expressed in terms of inhibitory zones around the DCME finished fabric samples were measured in millimetre and presented. From the image, it was clear that, the DCME finished fabric samples exhibited EXCELLENT inhibitory zones measuring 36mm and 37mm respectively for the tested bacterial cultures, Escherichia coli and Staphylococcus aureus.



Escherichia coli



Staphylococcus aureus

Fig. 1: Antibacterial activity of the DCME finished fabrics

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4.2. Antifungal activity – EN ISO 20645 test method of the DCME finished fabrics

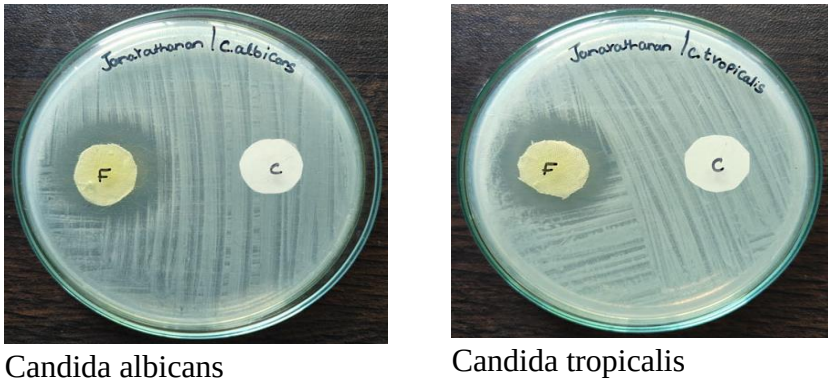
Sterile Czapek dox agar plates were prepared. Using sterile 4mm inoculating loop, one loop full of culture (Candida albicans and Candida tropicalis) was transferred by swabbing all around the surface of the agar plate and also covering the central area of the petridish. The test specimens (DCME finished fabrics and unfinished control fabrics) were cut into pieces (20mm in diameter) and placed over the media. The plates were incubated at 37°C for 48 hours. The inoculated plates were examined for the interruption of growth along the swabs of inoculum beneath the fabric and for a clear zone of inhibition beyond the fabric edge. The average width of the zone of inhibition around the test specimen calculated in mm.

Table-4.2.1: Antifungal activity of the DCME finished fabrics

Test Fungi	Zone of Inhibition (mm)	
	Sample	Control
Candida albicans	33	0
Candida tropicalis	32	0

Inference

In Table-4 and Fig. 4, the antifungal activity expressed in terms of inhibitory zones around the DCME finished fabric samples were measured in millimetre and presented. From the image, it was clear that, the DCME finished fabric samples exhibited GOOD inhibitory zones measuring 33mm and 32mm respectively for the tested fungal cultures, Candida albicans and Candida tropicalis.



Candida albicans Candida tropicalis

Fig. 4.2.2: Antifungal activity of the DCME finished fabrics

4.3. Physical properties of DCME finished fabric samples

Absorbency test - Wicking properties (AATCC TM 197)

Vertical Wicking of Textiles, is used to measure "the ability of vertically aligned fabric specimens to transport liquid along and/or through them" Wicking rate is a particularly important property that

measures a fabric's ability to remove sweat/liquid from contact with the skin. The wickability of the DCME extract dyed fabric sample was evaluated by time for wetting. During the analysis, the samples were conditioned in a standard atmosphere of 22ºC under 65% relative humidity for 24 hours. The pre-measured size (1.5cm x 5cm) of each test mounted on the glass slides was kept at immersed condition inside a reservoir containing distilled water. Control unfinished samples was also experimented in parallel. The wicking height of the advancing liquid front as a function of time was recorded by visual observation for 5 minutes. Using a standard ruler scale, the colour of water absorbed on the fabric surface was measured for each sample and the values were recorded.

Inference

Wicking absorbency was not reduced to significant level for DCME extract finished fabric samples when compared to control unfinished samples. This was evident from the obtained values presented in Table-5.

Table-4.3.1: Absorbency – Wicking test

Wicking height in cm	
Unfinished	**DC$_{ME}$ extract finished**
2.8	2.7

4.4 Tensile strength test (ASTM D 5035-2006 test method)

Tensile strength is the measure of the resistance of the fabric tensile load or stress in either warp or weft direction. It is the strength shown by a specimen subjected to tension as distinct from torsion, compression, or shear. Elongation defines the length to which a fibre may stretch before breaking. A sample of 12" X 2" was taken for the test. The tensile strength of the fabric was determined by cloth tensile strength tester. Tensile strength is performed using cut strip method. This test is used for treated or heavily sized fabrics. Three readings for every sample were taken and the average was calculated.

4.5. Air- permeability test (ASTM D 737-96 test method)

Air permeability of a fabric is the volume of air measured in cubic cm passed per second through 1 sq. cm for the fabric at a pressure of one cm. head of water. Air permeability can be measured using an instrument called Shirley Air Permeability Tester. Air permeability was determined in accordance with Test Method ASTM D-737-96. The conditioned specimens in the standard atmosphere for testing textiles, 21 ± 1°C and 65 ± 2 % relative humidity was tested unless otherwise specified in a material specification or contract order. The test specimens were carefully handled to avoid altering the natural state of the material. Placed each test specimen onto the test head of the test instrument, and performed the test as specified in the manufacturer's operating instructions. Read and recorded the individual test results in SI units as cm3/s/cm2.

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Table-4.5.1: Tensile strength and Air-permeability tests of DCME finished fabric and control fabric

S. No	Physical properties	Control cotton	DC_{ME} finished	Inference
1	Tensile strength	36.9 MPa/kgf	35.6 MPa/kgf	No significant difference
2	Air-permeability	101.6 $cm^3/cm^2/sec$	100.6 $cm^3/cm^2/sec$	No significant difference

Inference

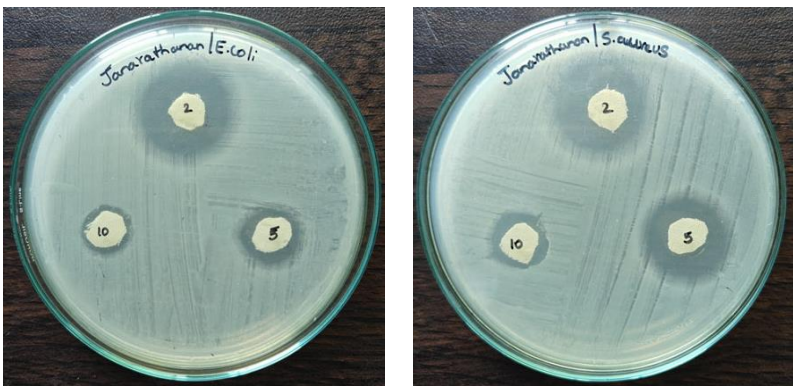
The tensile strength and air-permeability of DCME extract dyed fabric samples did not showed much difference on their respective values when compared to control plain fabric samples. This was evident from the values presented in Table-6. The obtained results indicated that the DCME extract after dyeing onto cotton fabrics did not altered or changed the nativity of the cotton fibres.

4.6. Wash fastness test (AATCC Test Method 124-1996) – 2nd, 5th and 10th wash

The samples (herbal finished) was washed based on the AATCC Test Method 124-1996 laundering procedure to see if the drug would persist through multiple washings. The treated samples were washed 2nd, 5th and 10th times. After each wash, antibacterial and antifungal activity of each fabric were qualitatively assayed using EN ISO 20645 test method as described in previous section.

Table-4.6.1: Antibacterial activity of fabric samples after wash

Washes	Zone of Inhibition (mm)	
	Escherichia coli	***Staphylococcus aureus***
2^{nd}	30	29
5^{th}	24	26
10^{th}	22	23



Escherichia coli Staphylococcus aureus

Fig. 4.6.2: Antibacterial activity of fabric samples after wash

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5. DISCUSSION

The integration of microencapsulated Delonix elata extract with Chitosan powder in cotton fabric finishing demonstrates a successful strategy for achieving multifunctional textile enhancements, including antibacterial activity, antifungal activity, and Physical properties. These outcomes are consistent with, and in several cases surpass, previously documented effects of either Delonix elata or Chitosan -derived phytochemicals when applied independently.

5.1 Antibacterial Activity

The antibacterial efficacy Sterile AATCC bacteriostasis agar plates were prepared. Using sterile 4mm inoculating loop, one loop full of culture (Escherichia coli and Staphylococcus aureus) was transferred by swabbing all around the surface of the agar plate and also covering the central area of the petridish. The test specimens (DCME finished fabrics and unfinished control fabrics) were cut into pieces (20mm in diameter) and placed over the media. The plates were incubated at 37°C for 24 hours. The inoculated plates were examined for the interruption of growth along the swabs of inoculum beneath the fabric and for a clear zone of inhibition beyond the fabric edge. The average width of the zone of inhibition around the test specimen calculated in mm.

5.2 Antifungal Activity

The antifungal activity of Delonix elata extracts was evaluated against the test organisms by well diffusion method. All the test cultures (Candida albicans and Candida tropicalis) were inoculated in a sterile Nutrient broth* and allowed to attain the growth for 24 to 48 hours. Sterile Mueller-Hinton Agar* plates were prepared and allowed to solidify. About 0.1% inoculum suspensions of the test organism (Candida albicans and Candida tropicalis) were swabbed uniformly over the agar surface separately. Under sterile conditions, 6mm wells were cut on the agar surface of each NA plates. About 20µl of each herbal extract fractions (three different concentrations – 100 µg/ml, 200 µg/ml and 300 µg/ml were prepared using DMSO) were loaded into the well and the plates were incubated at 37ºC for 24h. Standard antibiotic Clotrimazole is used as positive control in one well to compare the results. DMSO was used as negative control. The antifungal activity was evaluated in terms of zone of inhibition around the wells in all the inoculated NA plates. The inhibition clear zones were measured and recorded in millimeter.

5.3 Wash fastness

The samples (herbal finished) were washed based on the AATCC Test Method 124-1996 laundering procedure to see if the drug would persist through multiple washings. The treated samples were washed 2nd, 5th and 10th times. After each wash, antibacterial and antifungal activity of each fabric were qualitatively assayed using EN ISO 20645 test method as described in previous section.

5.4 Air permeability test

Air permeability of a fabric is the volume of air measured in cubic cm passed per second through 1 sq. cm for the fabric at a pressure of one cm. head of water. Air permeability can be measured using an instrument called Shirley Air Permeability Tester. Air permeability was determined in accordance

with Test Method ASTM D-737-96. The conditioned specimens in the standard atmosphere for testing textiles, 21 ± 1°C and 65 ± 2 % relative humidity was tested unless otherwise specified in a material specification or contract order. The test specimens were carefully handled to avoid altering the natural state of the material. Placed each test specimen onto the test head of the test instrument, and performed the test as specified in the manufacturer's operating instructions. Read and recorded the individual test results in SI units as cm3/s/cm2.

5.5 Limitations and Future Perspectives

Despite these promising results, the study has certain limitations. Performance assessments were limited to lab conditions and did not evaluate washing durability, UV exposure stability, or mechanical abrasion resistance, which are crucial for real-life applications. Additionally, while microencapsulation improved material stability, future work should explore release kinetics and long-term bioactivity. Further research should also investigate scalability and cost-efficiency of the Delonix elata synthesis and application process, along with life cycle assessments (LCA) to verify environmental impact.

6. CONCLUSION

Based on the analysis of the antibacterial, antifungal & Physical properties of the AATCC 130 treated fabric samples, several key observations can be made:

Antifungal Properties:

1. Synergistic Action

Delonix elata and chitosan work together to disrupt fungal cell walls, effectively inhibiting the growth of pathogens like Aspergillus and Candida.

2. Long-Lasting Protection

Microencapsulation allows gradual release of antifungal agents, ensuring continued effectiveness even after repeated washes.

3. Eco-Friendly and Safe

Both extracts are biodegradable and non-toxic, offering a sustainable and safe alternative to chemical fungicides for medical and activewear textiles.

Antibacterial Properties:

1. AATCC 130 does not evaluate antibacterial efficacy.
2. For antibacterial assessment, methods such as AATCC 100 or AATCC 147 are more appropriate.
3. However, fabrics with antibacterial finishes may show indirect benefits such as reduced odor or microbial, which could influence perceived cleanliness post-laundering.

Physical Properties:

S. No	Physical properties	Control cotton	DC_{ME} finished	Inference
1	Tensile strength	36.9 MPa/kgf	35.6 MPa/kgf	No significant difference
2	Air-permeability	101.6 $cm^3/cm^2/sec$	100.6 $cm^3/cm^2/sec$	No significant difference

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7. AUTHOR(S) CONTRIBUTION

The writers affirm that they have no connections to, or engagement with, any group or body that provides financial or non-financial assistance for the topics or resources covered in this manuscript.

8. CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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