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Application of textile finishing using neem extract: A move towards sustainability

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Abstract
Today, "sustainability" is a must. Additionally, the garment and textile sectors are not an exception. The manufacturing and finishing of textiles use a tremendous quantity of chemicals and emits hazardous materials into the environment. Therefore, it is crucial to reconsider and improve the chosen ingredients as well as the processing and finishing procedures. The methods must made eco-friendly from the beginning of the manufacturing process till the fabrics are finished. Special finishes are manufactured employing plants with their innate capabilities for novel finishes like antimicrobial, fragrance, antibacterial, insect repellent, etc. as the globe moves toward all alternatives for sustainability. Some of the plant-derived herbal extracts are broadly known for having antibacterial and antifungal properties. These organic goods can be found in great abundance and are widely available. They are cheap and not processed and can be used as raw materials for required applications on human skin as well on textile substrate. These plant products do not cause any significant harm or irritation to human skin. In the present study Neem herb is used to finish the cotton fabric. The Maceration procedure was used to prepare herbal methanolic extract from Neem leaves. The methanolic Neem extract has been imparted to cotton fabric as herbal antimicrobial finish using exhaust method. The outcomes of applying two different concentrations—3 g/l and 5 g/l—were compared. In terms of bacterial reduction, the finish's antibacterial activity was quantified. The bacterial count of treated samples was retested after 5 and 15 washing cycles according to standard ISO: 6330-1984E. According to the findings, bacterial reduction also decreased with higher extract concentration. Neem has been shown to be effective against bacterial development on cotton fabric. Neem leaves can act as a suitable replacement for dangerous chemicals that are currently in use. Therefore, the current inclination towards sustainability is imperative to keep up with the future demands balancing it with wellbeing of mother earth. The herbal processes mentioned in the paper give a huge boost to sustainability in textile industry.

Keywords: Neem, cotton, enzymatic scouring, antimicrobial, laundering and finish

Introduction
Textiles are organic polymers with a vegetable base. It was shaped for people to protect their body from external environmental factors like temperature, dust, sunshine, wind, and weather. Through the development of new high technology, clothing has played a significant role in human life from ancient times to the present. A variety of antimicrobial textiles now have a fast-expanding market thanks to consumer attitudes toward hygiene and an active lifestyle, which has in turn sparked dynamic research and development. As is well known, natural resources, especially those made from plants, are increasingly being used in textile production due to their wide availability, environmentally caring nature, low toxicity, and biocompatibility (Samanta and Agarwal 2009) [16]. An antimicrobial finish is applied to textiles to prevent the growth of microorganisms such as bacteria, fungi, yeast, and algae (Cho and Cho 1997) [3]. Natural fibres are more sensitive to bacterial attack than synthetic fibres because of their porosity and hydrophilic character. The structure of natural fibres traps water, oxygen, and nutrients, providing the perfect environment for microbial growth. On the other hand, coming into direct contact with a human body offers moisture, warmth, and nutrients that foster bacterial growth. Microorganism growth can result in unpleasant odours, stains, and deterioration of the fibre's mechanical properties, all of which could reduce a product's ability to perform its intended function. Additionally, in sensitive individuals, may increase skin infection and irritation (Haug, 2006) [6]. As a result, over the past few years, there have been far more bio-functional textiles having an antibacterial activity.

It is generally known that some herbal agents made from plants have antibacterial and antifungal properties. The paste-like materials from these plants and trees are being applied directly to wounds or skin from the very beginning. These organic goods can be found in great abundance and are widely available. They can be used as raw materials for necessary applications because they are inexpensive and unprocessed. These plant products are excellent biocompatibility to human skin and non-toxic in nature. Different parts of the plants and trees like stem, bark, leaf, and root can be used for special application on textile substrate. Neem exhibits a broad spectrum of antibacterial action against Gram-negative and Gram-positive pathogens, including M. tuberculosis (Chopra, 1952) [4]. Streptococcus mutans and S. faecalis have both been shown to be resistant to the antimicrobial properties of Neem extract (Almas, 1999) [1]. Neem extracts have been used to cotton and cotton/polyester blends in a relatively small number of experiments (Joshi *et.al* 2007, 2009 and Vaideki *et.al* 2009) [7, 8, 18]. The goal of the current research is to create a Neem leaf-based, environment friendly antibacterial treatment for textile use. Neem leaf extract is applied to cotton fabric, and the resulting samples are studied to determine their antibacterial properties.

Methodology

Material used

Grey fabric that is 100 percent cotton was purchased from nearby market. Enzymatic scouring was used to clean the fabric. The cotton fabric with plain weave, 286 GSM, and yarn count of 56/44 was used for the study. Methanol, acetic acid, and citric acid were the chemicals employed in the study.

Methods

Procedure for Neem Leaf Extraction

Neem (*Azadirachta indica*) leaves that were freshly matured and green were gathered and cleaned. In a hot air oven set at 40oC, leaves were left to dry. They were crushed and turned into a fine powder after being fully dried. The weight of dry powder was recorded. It was necessary to dry everything properly because failing to do so could contaminate essential substances. To obtain the concentrated methanolic extract, the powder was next subjected to an organic solvent (methanol). Extraction was done using the SOXHLET method in accordance with Mukherjee's standard (2002).

Enzymatic scouring of fabric

Cellulase enzyme was used as a pre-treatment for the fabric. Following the ideal standard conditions provided by Maps Enzymes Limited Ahmedabad, enzymatic scouring was conducted (India). Standard conditions were 0.5 gpl concentration, 60 °C temperature, pH of 5 for 30 minutes, and a 1:30 material to liquor ratio. The pH 5 was kept constant by using an acetate buffer. To counter the enzymatic impact, samples were removed after the enzyme treatment and washed in hot and cold water. Enzymatic scouring's goal was to clean the grey cotton fabric from impurities and improve the cotton fabric's capability to absorb antimicrobial agents.

Fabric treatment with Neem finish

A 100% cotton cloth was given an antimicrobial treatment using methanolic Neem leaf extract. The exhaust method, was used to apply the finish to the fabric.

Exhaust method

A bath was filled with an antimicrobial agent in two different concentrations (3 gpl and 5 gpl). The ratio of material to alcohol was set at 1:20. The sample was placed in an antibacterial bath with a pH adjustment of acetic acid from 5 to 6. A boil was attained in the bath, and this temperature was maintained for 30 minutes. The bath was cooled to room temperature after 30 minutes, at which point the sample was removed and given a warm water rinse. A cross-linking agent (8% owf citric acid) was used. Citric acid was administered as a follow-up treatment for 30 minutes at room temperature. Finally, samples were dried after being rinsed in cold water.

Evaluation of Fabric's Antimicrobial Activity

Controlled and Neem treated sample's antibacterial activity was assessed. 2x2 inch fabric samples were cut from Neem-treated cotton fabric. The samples were immersed in 5ml of sterile water in a petri dish for an entire night to compare the bacterial counts of treated and untreated samples. To assess bacterial growth, serial dilution (10^{-1}, 10^{-2} and 10^{-3}) method was used. A spreader was used to spread 0.1 ml of each of the prepared dilutions under laminar flow onto the prepared petri dish. For the purpose of promoting bacterial growth, the samples were kept in an incubator set at 30 °C for 24 hours. Bacterial colonies were counted visually (Quinn, 1961) [13].

Assessment of Finish Resistance to Washing:

All finished samples were washed in the "Launder-o-meter," by utilising the standard ISO: 6330-1984E and wash ability of the finish was evaluated. A regulated and specified number of washing cycles were performed on fabric samples. The resulting fabrics were initially cut into samples measuring 100 mm by 25 mm, and soap solution was made by combining the Standard soap powder - 4 gpl and Sodium carbonate (Na_2CO_3) - 2 gpl. By using a 1:20 M:L ratio, standard soap and sodium carbonate were combined with water. After a short while of stirring, a uniform soap solution was produced. The samples were put in the "Launder-o-meter's steel cups containing the soap solutions in order to wash the samples. The lid was closed and the cups were secured inside the device. The temperature was set at 30^0C and the timer to 10 minutes. All the samples were washed. Following washing, the samples were dried and again put through the specified number of washing cycles (5 and 15 cycles). The bacterial growth was then examined using serial dilution following incubation of the cloth samples on microbial agar.

Results and Discussion

Table 1: Bacterial reductions of finished samples

Conc. of the extract (g/l)	Bacterial reduction after treatment (%)	
	Grey fabric treated with Neem	Scoured and Neem treated fabric
3	72	96.66
5	75	96.80
Control sample	Confluent lawn of growth	

Table 1 shows clearly that the controlled sample had a confluent lawn of growth. The percentage reduction value after treating grey cotton fabric with 3 g/l and 5 g/l Neem extract with exhaust method was 72% and 75%, respectively. When the same approach was used to apply Neem extract to cotton fabric that had been enzymatically scoured, the percentage reduction value increased and was observed at

96.66% and 96.80%, with 3 g/l and 5 g/l respectively.
From the results, it can be inferred that bacterial reduction also improved as extract concentration increased. This can be as a result of the Neem extract bonding to the substrate through surface bond formation. Through the physical and ionic phenomena, the herbal extract adhered affects the microorganisms' cell membrane (Sarkar *et al*., 2003) [14]. According to Vyas *et al*. (2011) [19], who also support the findings, 5% concentrations of neem and aloe vera extract have low absorbance values, which are stronger indicators of antibacterial activity than 3% concentrations.
Furthermore, it was shown that samples of scoured cotton fabric treated with Neem herbs had far better percentages of bacterial reduction than samples of grey cotton treated with Neem extract.

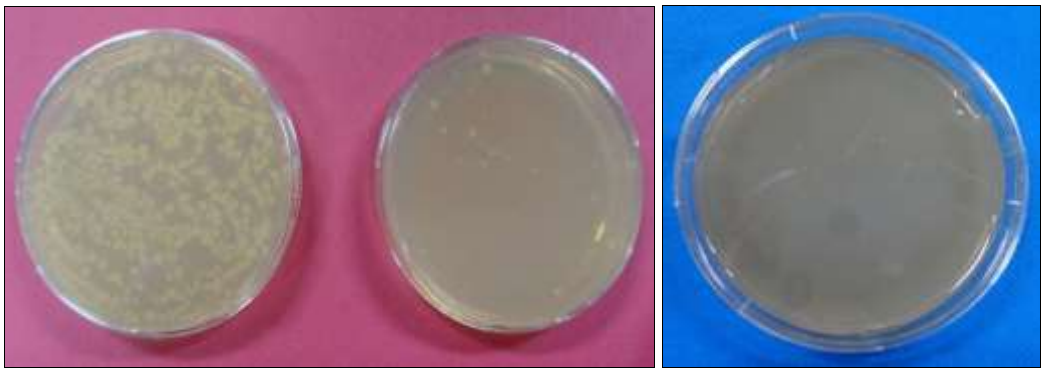

Fig 1: a. Photographs of Controlled sample, b. Only Neem treated c. Scoured & Neem treated samples

Controlled sample (a) Only Neem treated (b) Scoured and Neem treated (c)

Assessment of the performance of Neem application
The efficiency of the finish was assessed by washing all finished samples a predefined number of times in the "Launder-o-meter" in accordance with standard ISO: 6330-1984E. Once the fabric samples underwent microbiological testing, the bacterial growth was assessed after 5 and 15 washing cycles. The following findings have been reported:

Table 2: Performance of Neem finish on treated cotton fabric

Washing cycles	Conc. of the extract (g/l)	Bacterial reduction after treatment (%)	
		Grey fabric treated with Neem	Scoured and Neem treated fabric
0	3	72.0	96.66
	5	75.0	96.8
5	3	72.0	96.66
	5	75.0	96.8
15	3	66.0	90.0
	5	72.0	93.0
Control sample	Confluent lawn of growth		

The confluent lawn of growth was present in the control sample, as shown in Table 2. When 3 g/l of neem extract was used to treat grey cotton fabric, the percentage of bacterial reduction was 72%; when 5 g/l of neem extract was used, it was 75%. After 5 washing cycles, the finish's effectiveness was evaluated and found that the percentage of bacteria reduction in 3 g/l and 5 g/l Neem-treated grey sample remained constant. The percentage value was decreased up to 66 % and 72 % respectively with extract concentrations of 3 g/l and 5 g/l after 15 wash frequencies.
When scoured cotton fabric was finished with Neem extract the percentage of bacterial reduction was 96.66% at 3 g/l and increased to 96.8% at 5 g/l concentration. Up to 5 washing cycles, the percentage of bacterial remained constant. The percentage of bacteria reduced after 15 washing cycles and it was observed 90% with 3 g/l and 93% with 5 g/l concentration.
Thilagavathi and Kumar (2005) [17], who found that the antibacterial activity of cotton treated with pomegranate, prickly chaff flower, and neem steadily decreased as the number of wash frequencies increased, confirmed the findings.

Conclusion
The potential and practicality of natural compounds as antimicrobial finishes are supported by the current investigation. The compounds that were extracted exhibit effective antibacterial properties.
The following conclusions are drawn from the current study:

1. Neem, a natural antibacterial agent, has been shown to be successful in inhibiting bacterial growth on cotton fabric.
2. Enzymatically scoured fabric shows good antimicrobial activity than controlled fabric.
3. Bacterial growth declines when finish concentration rises.
4. Even after 15 washing cycles, the antibacterial effect on the cotton fabric sample treated with neem is still present.
5. As the active Neem ingredient isolated from Neem leaves and the process can be used as a viable substitute for dangerous conventional chemicals currently in use, antimicrobial finish, and sustainability.

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