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"Exploring the Impact of Pharmaceutical Antimicrobial Agents on Cotton Fabric"

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Abstract:

In contemporary times, a notable surge of attention has been directed toward the incorporation of pharmaceutical-derived antibiotic agents in response to the textile industry's demands. This paradigm shift arises from the environmental consequences associated with the application of synthetic counterparts. Within the scope of this inquiry, an in-depth exploration was undertaken to scrutinize the intrinsic antibacterial attributes inherent to organic cotton fabric (OCF) following treatment involving the integration of antibiotics, particularly Nystatin. The core objective underpinning this endeavour was the comprehensive evaluation of Nystatin's potential as an antibacterial agent tailored for textile applications. To assess the ramifications of this treatment, the treated OCF underwent rigorous testing against two distinct bacterial strains, specifically Escherichia coli and Staphylococcus aureus. The well-established agar disc diffusion method was employed for this purpose. The outcomes gleaned from these meticulous experiments unequivocally underscored the remarkable antibacterial efficacy showcased by the treated fabric. This was manifested through the emergence of discernible zones of inhibition (ZOI), with measurements averaging 12.23 ± 0.97 mm against E. coli and 14.43 ± 0.78 mm against S. aureus before any washing intervention was conducted.

Nevertheless, it is imperative to highlight that the antibacterial effectiveness exhibited a decline after undergoing successive washing cycles. Notwithstanding this decline, even post ten washes, the treated fabric exhibited a palpable level of antibacterial strength. These empirical revelations serve to accentuate the latent capacity inherent in Nystatin, categorizing it as a viable and fitting antibacterial agent capable of addressing the requisites of the textile sector.

Keywords: *Nystatin, Fabric, Antibacterial, Zone of Inhibition*

INTRODUCTION

Antimicrobial agents have garnered significant attention in the textile industry due to the growing demand for textiles that offer enhanced protection against microbial intrusion [1]. The need for antimicrobial finishing arises from its crucial role in mitigating the growth of pathogenic bacteria that can affect humans, animals, and plants. These agents find applications across sectors such as healthcare, food production, and agriculture, contributing significantly to disease prevention and hygiene maintenance [2]. Particularly, they play a vital role in healthcare environments, effectively combating bacterial infections and limiting their spread [2]. Furthermore, they are crucial in preventing bacterial contamination during the production of medical equipment [2]. However, the widespread use of synthetic antimicrobial agents raises environmental concerns and contributes to the emergence of antibiotic-resistant microorganisms, exacerbating existing public health challenges [3].

In response, the exploration of naturally derived, plant-based antibacterial alternatives is gaining momentum. Diligent researchers have focused on developing antibacterial agents sourced from nature, aiming to mitigate the environmental impact associated with synthetic agents [4]. This endeavor led us to delve into the potential of utilizing Nystatin for its inherent antibacterial properties, particularly in its interaction with organic cotton fabric (OCF) [5]. Nystatin is used to treat fungal infections of the inside of the mouth and lining of the stomach and intestines. Nystatin is in a class of antifungal medications called polyenes. It works by stopping the growth of fungi, bacteria that cause infection. [6].

The pressing need for antibacterial treatment on OCF is multifaceted. First, OCF, being a natural fibre, is prone to bacterial growth, particularly in clothing and textiles that come into direct contact with the skin. This can lead to issues like Odors, stains, and skin problems [7]. Second, applying antibacterial agents on OCF acts as a robust defines against the spread of bacterial diseases. In healthcare settings, this is vital, as patients are susceptible to infections from contaminated textiles. Lastly, the rising awareness of hygiene and infectious diseases drives the demand for antibacterial textiles [8]. For this problem synthetic antibacterial agent like Nystatin could be a better choice [9].

In line with this trend, prior researchers have explored the functionalization of OCF using various botanical sources. These include techniques like silver nanoparticle synthesis through chitosan reduction, zeolite treatment for antimicrobial efficacy, and the utilization of gardenia yellow natural dyes for nano silver production [10]. Regrettably, despite these advancements, the unique potential of Nystatin in functionalizing OCF remains relatively unexplored.

Hence, this study aims to investigate the inherent antibacterial efficacy of Nystatin when applied to OCF in relation to Escherichia coli and Staphylococcus aureus interactions [11]. The central hypothesis posits that the application of Nystatin onto OCF will exhibit significant antibacterial efficacy against these microbial strains. The evaluation method employed is the agar disc diffusion technique, offering a comparative perspective with a reference antibiotic agent. By venturing into this unexplored territory, this study contributes to the trajectory of sustainable, eco-friendly antimicrobial solutions derived from botanical sources, aligning with environmental concerns and sustainability imperatives. [12,13]

Objectives: -

1. The aim of the project is to develop a sample which is not affected by microbes.
2. Explain how antibiotic use can select resistant strains of bacteria.
3. Identify important mechanisms used by antibiotic stewardship programmes to decrease microbes resistant in hospitals.
4. Preventing cross infection by microorganism.
5. To control micro-organisms.
6. To protect from viral infections caused by pathogenic bacteria.
7. To optimize the rate of metabolism in microbes to reduce the generation of odour.

Applications:

Healthcare Textiles: Enhancing hospital textiles like gowns and wound dressings to prevent infections.

PPE Development: Creating effective reusable protective gear like masks and gloves.

Advanced Consumer Textiles: Improving sportswear and outdoor clothing with odor and microbial control.

Sustainable Solution: Reducing frequent washing, conserving water, and lowering detergent waste.

Smart Textiles: Integrating antimicrobial agents with sensors for pathogen detection.

Agricultural Use: Protecting crops as covers to limit harmful microorganism growth.

Veterinary Care: Crafting germ-resistant bedding for animals in clinics and shelters.

Filtration Systems: Enhancing air and water filters for cleaner environments.

Public Transport: Applying in seats and interiors to minimize germ spread.

Consumer Goods: Extending freshness of towels, bedding, and clothing.

2. Experimental [14]

The fabric weighed 90 g/m², featured a plain weave pattern, had a grey coloration, and possessed a thickness of 0.945mm. The antibiotic material for this study was Nystatin, sourced from pharmaceutical industry. This research aimed to assess the antibacterial capabilities of dyed organic nonwoven cotton fabric (OCF) incorporating Nystatin. The experimental procedures and chemical agents employed remained consistent with those detailed in the earlier study.

To evaluate the antibacterial attributes of OCF dyed with Nystatin, tests were conducted against Escherichia coli and Staphylococcus aureus bacteria, utilizing the standard test technique known as the agar diffusion plate test [18]. In this procedure, a solution was prepared by dissolving 32 g of dehydrated nutritional agar in 1000 mL of distilled water. The solution was subsequently sterilized and combined with a bacterial suspension. Following an 18-hour incubation period at 37°C, measurements were taken of bacterial growth and reduction (indicated by the zone of inhibition).

The evaluation encompassed both gram-negative bacteria (Escherichia coli) and gram-positive bacteria (Staphylococcus aureus). The assessment employed the zone of inhibition (ZOI) approach, specifically the agar disc diffusion test, to gauge the effectiveness of bacterial inhibition.

3. Result & Discussion

The results indicated that the treated fabric successfully hindered bacterial growth. Prior to undergoing washing, the ZOI measurements for treated OCF were 12.23 ± 0.97 mm and 14.43 ± 0.78 mm against E. coli and S. aureus bacteria, respectively. Notably, the antibacterial activity of the treated OCF was long lasting after post-washing. Fig.1

It is a common phenomenon for antibacterial treatments to lose potency over time due to the removal or degradation of active ingredients triggered by environmental factors like water, sunlight, and friction. In this instance, the gradual reduction in antibacterial activity might be attributed to the potential removal of Nystatin components from the fabric through washing. Nevertheless, the fact that the treated fabric retained some level of antibacterial effectiveness even after ten or more washes is promising. This hints at the likelihood that the treatment process could offer sustained antibacterial protection for a reasonable duration, making it valuable for scenarios requiring moderate antibacterial shielding.

Several factors could account for the continued antibacterial action of the treated OCF after ten plus washes. Firstly, the incorporation of Nystatin might have led to the development of a durable antibacterial deposit or coating on the fabric surface. This coating could serve as a reservoir of antibacterial compounds, gradually releasing them over multiple wash cycles. Nystatin could continue to permeate the fabric, creating a protective barrier against bacterial growth even after repeated washing. Moreover, the interaction between the phenolic compounds and the cellulose fibres of the fabric could enhance its resistance to bacterial colonization.

These findings are derived from laboratory testing and should be interpreted in the context of actual real-world applications. Practical efficacy, limitations, and shortcomings of the treatment technique would necessitate further investigation. Overall, this research highlights the potential of Nystatin as an antibacterial treatment for organic cotton fabric, offering sustained antibacterial effects even after washing. The precise mechanism underlying the antibacterial activity of Nystatin treated OCF remains to be fully elucidated and warrants more in-depth research. Nonetheless, several potential mechanisms have been proposed, including the presence of natural antibacterial compounds in the extract and potential alterations in fabric surface properties resulting from the treatment. It's possible that a combination of chemical and physical processes contributes to the observed antibacterial effects.

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4. Conclusion:

In conclusion, the outcomes of this investigation underscore the potential Nystatin as an effective antibacterial agent for organic cotton fabric. The treatment exhibited substantial antibacterial efficacy against both Escherichia coli and Staphylococcus aureus. Prior to laundering, the treated organic cotton fabric displayed a noteworthy average zone of inhibition (ZOI) of 12.23 ± 0.97 mm against E. coli and 14.43 ± 0.78 mm against S. aureus, affirming its robust antibacterial performance. Notably, even after undergoing repeated washing cycles, the treated fabric maintained a residual level of antibacterial activity, demonstrating its durability.

These findings propose that Nystatin holds promise as a pharmaceutical based antibacterial solution for textile applications. This approach presents distinct environmental advantages compared to natural or all other antibacterial treatments, which can carry antibacterial action as well as antibiotic-resistant bacterial strains. However, to fully harness the potential of this treatment, further research is imperative. Optimization of the treatment methodology and a comprehensive understanding of the underlying mechanisms driving antibacterial action are areas that require more exploration.

Subsequent real-world testing is indispensable to gauge the practical effectiveness of the treated organic cotton fabric in genuine applications. Ultimately, this study underscores that Nystatin possesses the potential to be a valuable antibacterial agent in the realm of textile applications. Furthermore, considering its positive outcomes for enhancing the functionality of organic cotton fabric, it's prudent to extend this exploration to other cellulosic textiles in the pursuit of future antibacterial applications, utilizing pharmaceutical drug Nystatin.

Fig. 1 Antibacterial activity of Nystatin treated organic cotton fabric against (A) Escherichia coli, and (B) Staphylococcus aureus.

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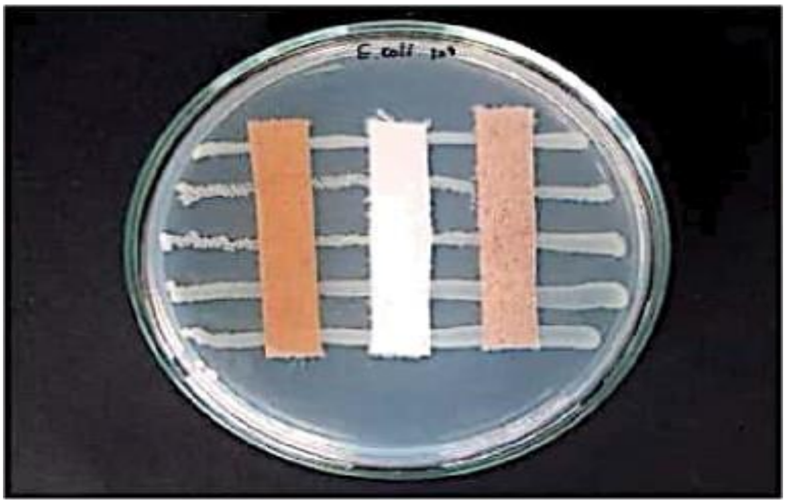

Fig. 2 Fabric Sample

Table 1

The antibacterial performance of organic cotton fabric using Nystatin

Fabric Type	Antimicrobial agent	Wash Cycle	*E. coli* ZOI (mm)	*S. aureus* ZOI (mm)
Organic Cotton	Nystatin	Before Washing	12.23 ± 0.97	14.43 ± 0.78
Organic Cotton	Nystatin	First Washing cycle	9.14±0.51	12.01±0.94
Organic Cotton	Nystatin	Second Washing cycle	6.45±0.25	9.85±0.61

Note: ±, Standard deviation, ZOI – Zone of Inhabitation.

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