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Antimicrobial activity of fabrics treated with *Quercus Infectoria* extract for foot odour control

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ABSTRACT

This study concentrates on controlling the development of foot odor causing bacteria while wearing socks. Hence 100% bamboo fabric, nylon/bamboo and cotton/nylon union fabrics were produced using socks knitting machine and they were treated with natural antimicrobial agent, *Quercus Infectoria* (Gallnut). The gallnut treated fabrics were tested for antimicrobial activity against the foot odour causing bacteria such as *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Propionibacterium acnes* and *Escherichia coli* using agar diffusion method and the zone of inhibition was identified for all the samples. The result shows that gallnut treated bamboo fabrics and its blend shows better antibacterial activity than cotton and nylon. © 2013 Trade Science Inc. - INDIA

INTRODUCTION

Foot odor is a type of body odor that affects the feet of humans and produces unpleasant smell especially for the sports people. This is mainly due to the generation of sweat on the foot. Though Sweat is basically a combination of salt and water, it doesn't have a distinctive smell of its own. The smell is actually caused by bacteria that are normally present on the skin which is attracted by the sweat, feed on and excretes waste that creates strong odor. Therefore, more smell is created with factors causing more sweating, such as wearing shoes and/or socks with inadequate air ventilation for many hours^[1].

Since foot odor is caused by bacteria digesting sweat, there are two main ways to reduce the stink. One is to decrease the amount of bacteria on our feet and the other one is to decrease the amount of sweat that collects on our feet. The amount of bacteria on feet can be reduced by wearing clean socks and to wash

the feet with antibacterial soaps. The amount of sweat that collects on our feet can be reduced by wearing well-ventilated shoes and socks, applying an antiperspirant on our feet and wearing socks preferably made of cotton or other absorbent materials that absorb a lot of sweat and transfer it to the environment to keep the skin dry so that the bacteria cannot feed on it^[2]. The most commonly used materials to manufacture socks are cotton, polyester and nylon.

The use of polyester or nylon socks may increase perspiration and therefore may intensify the foot odor. These problems can be overcome by using bamboo fiber as it has quick sweat evaporation and natural antibacterial properties. It can also be blended with cotton and nylon to enhance the properties towards the absorption of sweat.

One of the odor causative agent of sweat is propionic acid (propanoic acid), breakdown product of amino acids by *Propionibacteria*, which thrive in the ducts of adolescent and adult sebaceous glands thus

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produces vinegar-like odour. Isovaleric acid (3-methyl butanoic acid), another source of foot odor is a result of *Staphylococcus epidermidis* bacterial action, present in several strong cheese types^[2]. *Staphylococcus aureus* and *Escherichia coli* bacteria are also commonly present in our skin which produces odour during sweating

This bacterial action can be reduced by using several antimicrobial agents obtained from natural resources. One such antimicrobial agent is Gallnut (*Quercus Infectoria*) that contains the mixture (60-70%) of gallotannin, ellagic acid, starch and glucose. The dyestuff in the tannin of gallnut is ellagic acid, which exhibits dyeing properties because of auxochrome group (-OH) together with other chromogen groups and its natural mordanting property enhances dyeability in cellulosic fabric^[3]. Both tannic and gallic acid extracted from galls are powerful astringents. Tannin in galls has good anti-viral and anti-septic property. They are also used in the treatment of diarrhea, dysentery, hemorrhoids, gonorrhea, vaginal infections, including leucorrhea.

The aim of this work is to inhibit the foot odour causing bacteria *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Propionibacterium acnes* and *Escherichia coli* by applying natural antibacterial agent on knitted fabrics made out of 100% Bamboo, Bamboo/Nylon and Cotton/Nylon. Antimicrobial activities of these fabrics were assessed by qualitative testing of fabrics using Agar diffusion method (AATCC 100).

MATERIALS AND METHODS

Yarn

Three different yarn samples of Cotton, Bamboo and Nylon were selected based on market analysis. The count of selected cotton, bamboo and nylon yarns was 30^s, 30^s and 70/2^s respectively.

Antimicrobial agent

Natural antimicrobial agent, Gallnut (*Quercus infectoria*) was purchased from M/s. Kannan Herbals, Coimbatore, India. All other chemicals used for the extraction of gallnut were of LR grade.

Test microorganisms

The bacteria used in the study include *Staphylococcus aureus*, *Escherichia coli*, *Propionibacterium*

acnes and *Staphylococcus epidermidis*, were the clinical isolates obtained from R&D Bio-technology, Coimbatore, India.

Knitting

The yarns procured were knitted using socks knitting machine in three different combinations and their parameters are shown in the TABLE 1.

TABLE 1 : Specifications of knitted fabrics

S.No	Material Structure	Wales Per Inch (WPI)	Course Per Inch (CPI)
1	Cotton/Nylon single jersey	21	27
2	Bamboo/Nylon single jersey	20	26
3	100% Bamboo single jersey	21	20

All the knitted samples were bleached under standard conditions.

Preparation of extracts

The gallnut seeds were collected and grind into fine powder. It was extracted by adding 5g of gallnut powder with 100 ml of acetone in a conical flask and heated at 60°C under reflux for 1hr. The extract was then filtered using Whatmann no.1 filter paper and then concentrated under Vacuum at 40°C by using a Rotary Evaporator.

Application of extracts on knitted fabrics

1" X 1" fabric was immersed in solution having required concentrations of extracted gallnut solution and sodium chloride for 1 hr at 40°C and stirred well for 45 minutes with the liquor to material ratio 50:1. Various concentrations of the extracted gallnut solution used were 5%, 10%, 15%, 17% and 20% w/v with various NaCl concentrations 10g/l, 20g/l and 30g/l. The treated samples were taken out, squeezed and air dried without subjecting them to washing process. Finally an optimized concentration of 17% w/v extracted gallnut solution and 20g/l NaCl treated sample was used for the assessment of antibacterial activity.

Estimation of antibacterial activity

The agar diffusion method is a relatively quick and easily executed semi-quantitative test to determine antibacterial activity of diffusible antimicrobial agents on treated textile material. The bacteria were grown in nu-

trient broth medium. Using x100 dilution from a 3 hour culture, test organisms were swabbed over the surface of agar plates. 2 cm ± 0.1 cm diameter discs of the test fabric and control fabric were then gently pressed on to the surface of the plate. The plates were incubated at 37°C for 18 – 24 hours. The antibacterial activity of fabrics was assessed by the diameter of the zone of inhibition in comparison to the control fabric^[4].

100% bamboo fabrics. The results show that gallnut treated 100% bamboo material has higher inhibitory effect towards *Escherichia coli*, *Staphylococcus*

RESULTS AND DISCUSSIONS

Influence of gallnut on antimicrobial activity

TABLE 2 and Figure 1 & 2 show the difference in antimicrobial activity of gallnut treated and untreated

TABLE 2 : Antimicrobial activity of treated and untreated bamboo samples

Bacterial agent	Zone of inhibition (mm)	
	100% Bamboo (Treated)	100% Bamboo (Untreated)
<i>Escherichia coli</i>	27	-
<i>Staphylococcus aureus</i>	24	23
<i>Staphylococcus epidermidis</i>	22	15
<i>Propionic bacterium acnes</i>	25	14

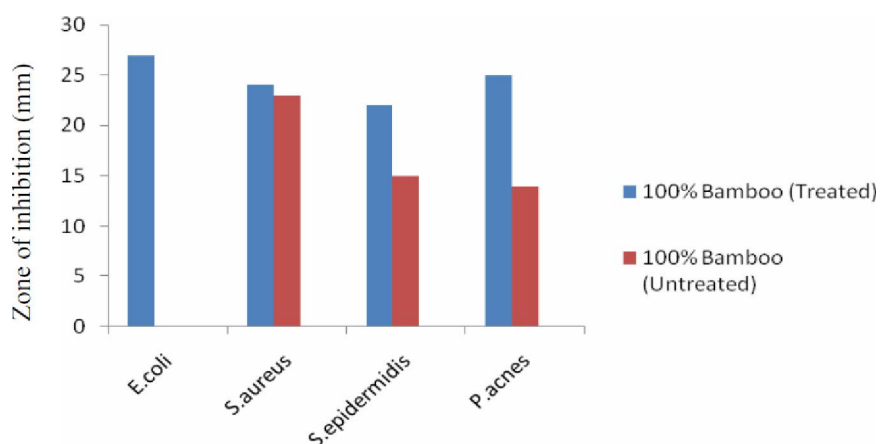


Figure 1 : Effect of gallnut on treated and untreated 100% bamboo fabrics

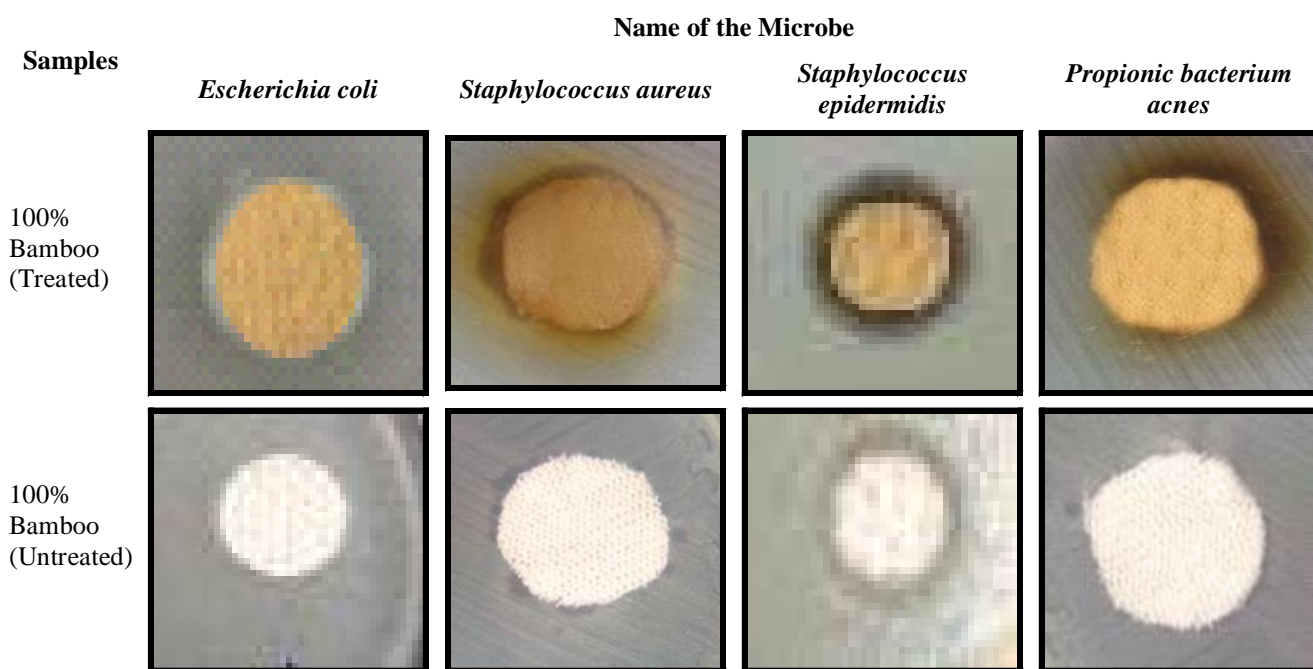


Figure 2 : Zone of inhibition of gallnut treated and untreated bamboo samples against the foot odour causing bacteria

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aureus, *Staphylococcus epidermidis* and *Propionic bacterium acnes*. This may be due to the presence of tannin in gallnut which has good antimicrobial property.

Influence of fabric on antimicrobial activity

TABLE 3 and Figure 3 & 4 show the antimicrobial activity of *Quercus Infectoria* on treated knitted samples

against various bacteria such as *E.coli*, *S.aureus*, *S.epidermidis* and *Propionic bacterium acnes*. In Cotton/ Nylon, gallnut shows better activity against *S.aureus* when compared to other microbes. In Bamboo/Nylon, gallnut shows better activity against *S.aureus* than other microbes. 100% bamboo fabric treated with gallnut, shows better activity against *E.coli* when compared to other microbes.

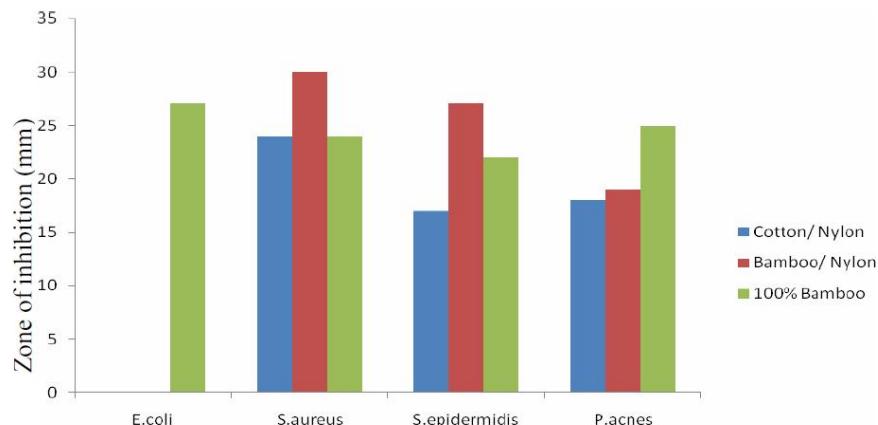


Figure 3 : Effect of gallnut on treated knitted samples

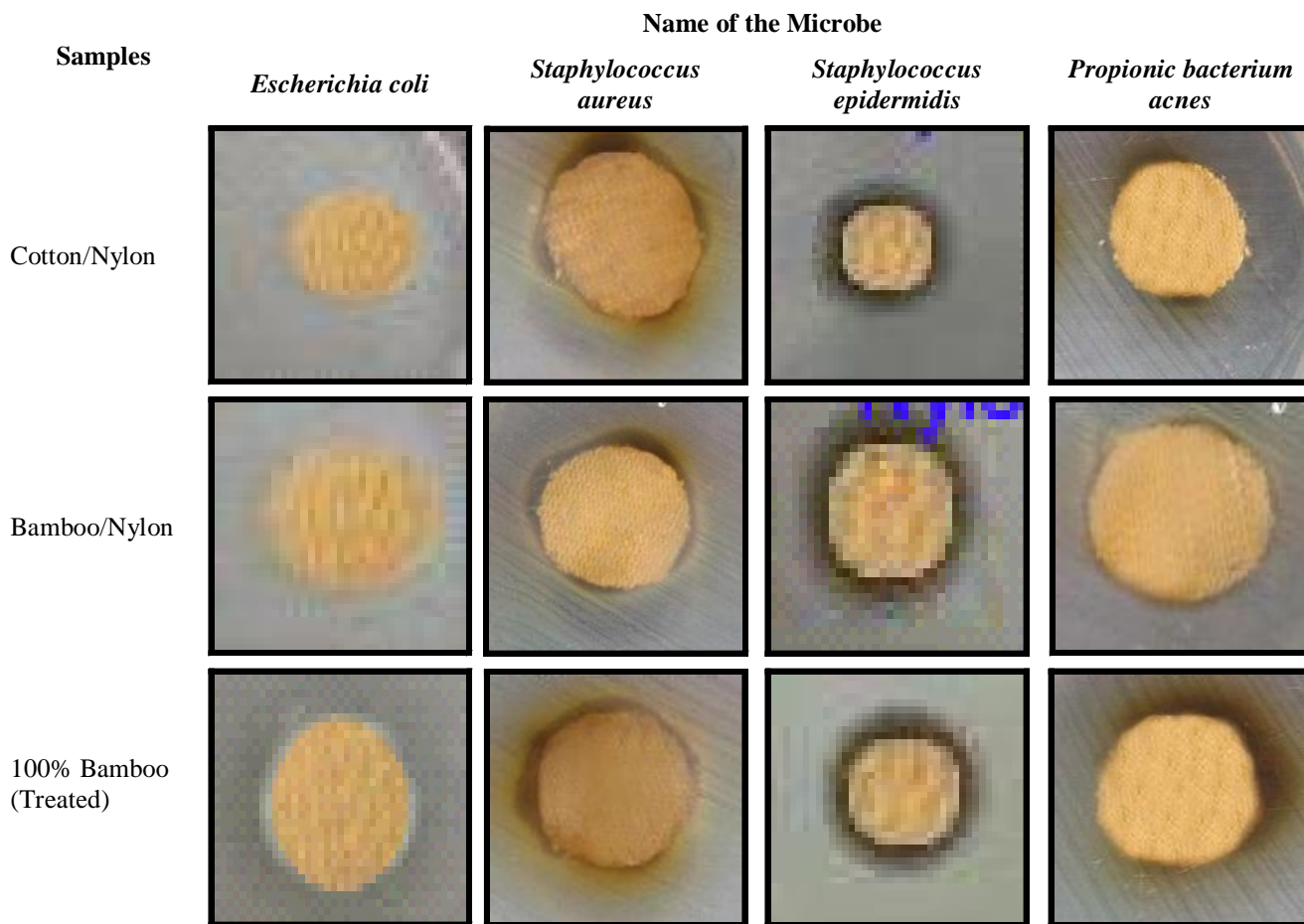


Figure 4 : Zone of inhibition of gallnut treated samples against the foot odour causing bacteria

TABLE 3 : Antimicrobial activity of gallnut treated knitted samples

Bacterial agent	Zone of inhibition (mm)		
	Cotton/ Nylon	Bamboo/ Nylon	100% Bamboo
<i>Escherichia coli</i>	-	-	27
<i>Staphylococcus aureus</i>	24	30	24
<i>Staphylococcus epidermidis</i>	17	27	22
<i>Propionic bacterium acnes</i>	18	19	25

While considering *S.aureus* and *S.epidermis*, Bamboo/Nylon shows better activity followed by 100% Bamboo and Cotton/Nylon. 100% bamboo shows better resistant to *Propionic bacterium acnes* followed by Bamboo/Nylon and Cotton/Nylon and the antimicrobial activity against *E.coli* is only achieved in 100% Bamboo treated sample. The combination effect of “bamboo kun”, a natural antibacterial element in Bamboo and tannin in gallnut, leads to increased resistance against microbes of bamboo and its blends. The antimicrobial activity of gallnut varies with the type of fabric may be due to the interaction of the chemical components present naturally in their structure.

CONCLUSION

It is observed that gallnut treated 100% Bamboo knitted fabric is found to have good antibacterial activity against the foot odour causing bacteria *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Propionic bacterium acnes* when compared to Bamboo/Nylon, Cotton/Nylon and Bamboo untreated samples and this is achieved mainly due to the combined effect of gallnut and bamboo. From the above findings it is indicated that there is a good scope to produce odor control socks by the application of gallnut on bamboo fabrics since the gallnut provides good antimicrobial protection and also good dyeability to fabrics due to the presence of mordant in it.

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