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Antimicrobial Activity of Some Natural Textile Dyes

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Abstract

In this study, antimicrobial activity of some natural dyes in solution and % bacterial reduction of dyed wool samples were investigated. Four natural dyes; curcumin (*Curcuma longa.),* stinging nettle (*Urtica dioica)* , walnut leaf *(Juglans regia),* camomile *(Matricaria chamomilla)* were tested against *Staphylococcus aureus* ATCC 25923, *Shigella sonnei* RSKK 877, *Escherichia coli* ATCC 35218, *Bacillus megaterium* RSKK 5117, *Bacillus subtilis* RSKK 244, *Bacillus cereus* RSKK 863, *S.epidermidis*, *Salmonella* 21.3 by using disc diffusion method. In the next set of the experiments the antimicrobial activity of dyed wool specimens were tested. A reduction of bacterial growth were determined on wool samples dyed with natural dyes.

Keywords: Natural dyes, antimicrobial activity, *Curcuma longa, Urtica dioica, Juglans regia, Matricaria chamomilla*

INTRODUCTION

In recent decades, there has been an increasing interest in organic materials towards the prevention of microbial attack on textiles and food because of synthetic products' disadvantage [1]. Textile materials and clothing are known to be susceptible to microbial attack, as these provide large surface area and absorb moisture required for microbial growth. This often leads to objectionable odour, dermal infection, product deterioration, allergic responses and other related diseases. This necessitates the development of clothing that could provide a desired antimicrobial effect [2].

The major classes of antimicrobial agents for textile include organo-metalics, phenols, quaternary ammonium salts, and organo-silicons. Safety, non-toxicity and biodegradability are required for antimicrobial agents, and the active ingredients used in antimicrobial finishes need to be registered after they have been demonstrated effective and safe to use [3]. Textiles dyed with these natural dyes can be very useful in developing clothing for infants, elderly and infirm people to protect them against common infections [2].

Many of the plants used for dye extraction are classified as medicinal, and some of these have recently been shown to possess remarkable antimicrobial activity. *Punica granatum* and many other common natural dyes are reported as potent antimicrobial agents owing to the presence of large amount of tannins. Several other sources of plant dyes rich in naphthoquinones such as lawsone from henna, juglone from walnut and lapachol from alkannet are reported to exhibit antibacterial and antifungal activities [2].

Curcumin, a common non-toxic natural dye used in textiles and food, has antimicrobial activity on wool. A common dyeing process, either pad or batch, provides wool with colour and antimicrobial properties. Pharmacological studies have demonstrated that curcumin used in traditional medicine results in anti-imflammatory, antifungal, and antitumor activities [3].

Matricaria chamomilla flowers give yellow colour. *Matricaria chamomilla's* dyestuffs are apigenin, luteolin and quercetin [4].

Some parts of stinging nettle are used for food, dye, fertilizer, fibre industry, cosmetics and folk medicine. Yellow colour can be obtained from stinging nettle roots. *Urtica dioica* (stinging nettle) leafs are used in chlorophyl extraction to obtain commercial green dyestuff (E140) [5].

Juglans regia (walnut) leafs and hull have tannins, essential oils and juglon. Both leafs and hull of walnut are major natural dyestuffs in our country and some areas of the world [6].

MATERIALS AND METHODS

Natural dyes and test microorganisms

Curcumin (*Curcuma longa*), nettle (*Urtica dioica*), walnut leaf (*Juglans regia*), camomile (*Matricaria chamomilla*) were used for preparing natural dyes. Cultures of fallowing microorganisms were used in this study: *Bacillus megaterium* RSKK 5117, *Bacillus subtilis* RSKK 244, *Bacillus cereus* RSKK 863, *Streptococcus epidermidis, Shigella sonnei* RSKK 877, *Salmonella* sp. 21.3, *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 35218.

Natural dyes application

To prepare aqueous dye solutions of these plants, 10 g of each powders were added to 300 ml of distilled water and boiled for 60 min at 100°C. Then hot dye solutions were filtered.

Dying wool samples

Wool was dyed by the standard method prescribed for natural dyes. The dyeing was carried out at 1:30 MLR (material to liquor ratio), for 30 min at 80 ^{0}C at neutral pH. Dyed samples were further treated with the aluminium potassium sulfate ($KAl(SO4)_2.12\ H_2O$) as mordant (0.5 g/l) at 60 ^{0}C for 20 min, and rinsed in hot and then cold water.

Antimicrobial screening test

Susceptibility of the bacterial strains to the natural dyes was investigated using the disk diffusion method. The culture suspensions were prepared and adjusted against 1 Mc Farland turbidity standard tubes. Mueller Hinton Agar medium (15 ml) was inoculated with 100 µl cultures. Dyes were sterilized by filtration through a 0.45µm membrane filters. Empty sterilized discs of 6mm were each impregnated with 20µl, 40µl, 60µl, 80µl, and 100µl natural dyes. Discs were placed on agar plates, and the plates were incubated at 37 ^{o}C for 24 h. The inhibition zones formed on the medium were evaluated in mm. All experiments were performed in duplicate.

In the next set of experiments the antimicrobial activities of dyed wool specimens were tested. The 1 g fabric (dyed and undyed) was introduced into 100 ml nutrient broth inoculated with the desired microbe and incubated at 37 ^{o}C overnight for 16 h. The reduction of bacterial growth by dye was expressed as follows:

$$R = 100(A-B)/A$$

Where R=% reduction in bacterial population; A= absorbance (660 nm) of the media inoculated with bacteria and undyed fabric; B= absorbance (660 nm) of the media inoculated with bacteria and dyed fabric [2].

RESULTS AND DISCUSSION

Inhibition activity of curcumin natural dye against 7 of test bacteria were determined between 10,7–18,3 mm. The other dyes didn't show inhibition activity to test bacteria. We also tested antimicrobial activity of different amounts of curcumin dye solutions, 20µl, 40µl, 60µl, 80µl, 100µl (Table 1 and Table 2).

Table 1. Zone of inhibition (diameter in mm) for natural dye against test microorganisms (100µl dye solution).

Test Bacteria	*Curcuma longa*	*Urtica dioica*	*Matricaria chamomilla*	*Juglans regia*
B.cereus RSKK 863	-	-	-	-
B.megaterium RSKK 5117	10,7	-	-	-
Shigella sonnei RSKK 877	16,8	-	-	-
S.aureus ATCC 25923	17,8	-	-	-
B.subtilis RSKK 244	16,9	-	-	-
Escherichia coli ATCC 35218	15,2	-	-	-
Salmonella 21.3	18,3	-	-	-
S.epidermidis	16	-	-	-

-: there is no inhibition

Table 2. Zone of inhibition (diameter in mm) for curcumin natural dye against test microorganisms (20µl, 40µl, 60µl, 80µl dye solutions).

Test Bacteria	Curcumin Dye			
	20 µl	40 µl	60 µl	80 µl
B.cereus RSKK 863	-	-	-	-
B.megaterium RSKK 5117	-	-	-	-
Shigella sonnei RSKK 877	9,7	10	11,4	13
S.aureus ATCC 25923	10,1	13	13,7	15
B.subtilis RSKK 244	9	13,7	14,9	16,2
Salmonella 21.3	12	12,3	14,3	17,4
S.epidermidis	9,5	12,4	14,3	16,3
E. coli ATCC 35218	-	-	12,5	14,1

-: there is no inhibition

The antimicrobial efficacy of a dye compound can vary when it is present in solution and when it is held by a textile substrate. Since curcumin exerted antimicrobial activity against most of the bacteria in solution, we made an attempt to determine its inhibition potential on dyed textile substrate (wool fabric).

A reduction of 15,6 % in bacterial growth was observed on a wool sample dyed with *Curcumin against B. megaterium* RSKK 5117. There was no activity against the other organisms.

Singh et.al. tested four natural dyes, *Acacia catechu, Kerria lacca, Quercus infectoria, Rubia cordifolia* and *Rumex maritimus* against common pathogens, *E. coli, B. subtilis, Klebsiella pneumoniae, Proteus vulgaris, Pseudomonas aeruginosa. Q. infectoria* dye was the most effective and showed inhibition zone thereby indicating best antimicrobial activity against all the microbes tested. A reduction of 10e15% in bacterial growth was seen on a wool sample dyed with *A.. catechu* and a reduction of 15e25% on wool sample dyed with *Q.infectoria* [2].

Han and Yang (2005) also exhibited that an inhibition rate of 70% was against *Staphylococcus aureus* when 0.01% of curcumin was applied to the fabric and while inhibition rate of 70% was against *E. coli* when 0.05% of curcumin. However, inhibition rate of more than 95% was obtained against both *S. aureus* and *E. coli* when 0.2% of curcumin was applied to the fabric [3].

In another study, 11 natural dyes were tested against 3 gram negative bacteria. Seven of these dyes showed activity to one or more bacteria. The results showed that the natural dyes had antimicrobial activity and inhibited the growth of *E.coli* and *Proetus vulgaris* [7].

There was no correlation between antimicrobial activity of curcumin solutions and %bacteria reduction on dyed textile substrate in our study..Antimicrobial activity is related with chemical structure of the dye sample. Further phytochemical research is needed to determine the effect of dye structure on inhibition.

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