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Full Length Research Paper

Experimental study on antimicrobial activity of cotton fabric treated with aloe gel extract from *Aloe vera* plant for controlling the *Staphylococcus aureus* (bacterium)

D. Jothi

Textile Engineering Department, Bahir Dar University, Bahir Dar, Ethiopia. E-mail:jothi_bahirdar@yahoo.co.in.

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Biotechnology is a frontier area in science and technology having significant commercial applications in healthcare, agriculture, process industry and service sectors the world over. Ethiopia is in an advantageous position to harness the potential of biotechnology due to its unique strengths such as availability of technical expertise, skilled manpower, rich bio-resources and progressive government policies. The country is also rapidly emerging as a major market for biotech products. Today, new processes and products are closely linked with biotechnology in many research and industrial fields. There are the most diverse possibilities for its profitable use in the textile industry too. In this study, aloe gel has applied to 100% cotton fabric to develop antimicrobial fabric. In order to optimize the process parameter, cotton fabric was treated with *Aloe vera* extract (*Aloe barbadensis* Mill) at various concentrations that is 1, 2, 3 and 5 gpl at 60°C for 30 min by pad-dry –cure method. Methanol was used as a solvent for aloe gel extraction from *Aloe vera* plant. The finished fabric samples have been tested for activity as per the ATCC (Agar diffusion) method and quantitative analysis test method. The aloe gel treated fabrics exhibited antimicrobial activity against the Staphylococcus aureus (ATCC 6538). The treated cotton fabrics have shown excellent antimicrobial activity at 5 gpl concentration. The wash durability of the treated sample was found good even after 50 wash.

Key words: Biotechnology, agar plate, micro organism, *Aloe vera.*

INTRODUCTION

Biotechnology also offers the potential for new industrial processes that require less energy and are based on renewable raw materials. It is important to note that biotechnology is not just concerned with biology, but it is a truly interdisciplinary subject involving the integration of natural and engineering sciences. Biotechnology is like an enormous "factory" which not only provides other industries with innovative ideas, but also supplies the appropriate know-how. Now familiar with the application of modern biotechnology in medicine and agriculture: so-called red and green biotechnology (Sarkar et al., 2003). There is less general awareness of the white variety: the use of biotechnology for industrial applications. Cheese production, golden rice, the manufacture of insulin and interferon, biosensors, enzymes in detergents - these are all examples of biotechnology in action, a sector that is constantly growing and expanding into other industrial sectors, a true driving force of interdisciplinary applications. The current trend deals with the potential of biotechnology in the textile industry.

Now, there is a good deal of demand for the fabrics having functional/speciality finishes in general but antimicrobial finishes in particular to protect human being against microbes (Klaus, 2001). The application of antimicrobial textile finishes include a wide range of textile products for medical, technical, industrial, home furnishing and apparel sectors. Though a number of commercial antimicrobial agents have been introduced in the market, their compliance to the regulations imposed by International Bodies like EPU is still unclear. Recent developments on *Aloe vera* (a naturally occurring biopolymer) have opened up new avenues in this area of research (Grind-lay and Reynolds, 1986).

A. vera plants are well known for their medicinal and healing properties from centuries. *A. vera* called the „miracles plant" or the „natural healer". *A. vera* is a plant of many surprises. The healing properties of the succulent plant *A. vera* have been known for thousands of years.

Belonging to the lily family and related to the onion, garlic and asparagus, evidence supporting the early use of *Aloe* was discovered on a Mesopotamian clay tablet dating from 2100 BC (Ghannam and Davidson Pillai RK). In Cairo in 1862, George Ebers, a German Egyptologist, bought a papyrus, which had been found in a sarcophagus excavated near Thebes a few years earlier.

The present investigation aims at developing an eco friendly natural herbal finish from *A. vera* extracts for various textile applications. Some selective species of *A. vera* plants were identified and screened for their activity and the extracts were applied to cotton fabrics. An extensive study was conducted to assess the antibacterial effectiveness of the herbs by employing standard test methods and the findings are discussed in this paper.

MATERIALS AND METHODS

Fabric

Bleached Cotton fabrics with the following specification were used.
Ends per centimetre – 28.
Picks per centimetre – 25.
Weave – Plain.
Count – 40 x 40 Ne carded.

Chemicals

Citric acid and methonal.

Aloe gel-Antimicrobial agent [1 grams per litre (gpl), 2,3 ,4 and 5 gpl]

A. gel extract was extracted from *Aloe vera* plant available at our University campus.

Equipments

Padding mangle, Laundro meter, SS Extractor and Curing chamber

Experimental procedure

500 g of grinded *A. vera* leaves were taken into a jacketed SS extractor and subjected to steam purging which helps in removal of volatile impurities such as pesticides. The desired solvent was added in the ratio of 1:4 to 1:6 of *A. vera*: solvent. Extraction was done for 2-4 h at temperatures of 40-45ë C. The mixture was constantly stirred and samples of decoction were taken out at regular intervals to check the concentration of the active material in the extract. When the concentration level becomes almost constant, the mixture was drained and filtered using a centrifuge. The methonolic crude extract was treated with 1% aqueous hydrochloric acid for 30 min after removal of neutral impurities with methanol which makes the extract in aqueous form. The extract was washed with water at 90ëC which remove the residual trace of methanol present in the extract. The filtrate (extract) is transferred to a storage vessel.

Antimicrobial finish application

The fabrics were immersed in the 1, 2, 3, 4 and 5 gpl concentration of methanol extracted aloe gel for five minutes and padded on a adding mangle indivually in the presence of citric acid to maintain 5.5 pH. It was again immersed in the solution for another five minutes and repeated and squeezing process to get a wet pick up of 80% on weight of the fabric.

The fabric was then dried at 80ëC for 3 min and cured at 110ëC for 2 min on a lab model curing chamber.

Antimicrobial activity assessment

Antimicrobial activity was evaluated by both qualitative and quantitative test methods. The following are the descriptions of test methods employed for this study.

Antimicrobial testing

Antimicrobial testing was carried out by using the shake flask method. Tests were conducted against the *Staphylococcus aureus* (bacterium) as per ATCC 6538 Artificial concentration of bacterium that is 2.8 x 10^4 /ml was treated with 1 g of the fabric separately in a test tube. The test tube was shaken at 35ëC for 1 h on a rotary shake at 100 rpm. The reduction of colonies was calculated using the following equation:

$$\text{Reduction rate in the number of colonies (\%)} = \frac{(A-B)}{A} \times 100$$

Where;
A = Number of colonies before shaking.
B = Number of colonies after 1 hour shaking.

Determination of antimicrobial activity by using agar plate method

Treated and untreated control fabric samples placed in intimate contact with AATCC bacteriostasis agar, which has been previously inoculated (Mat culture) with an innoculam of test organisms. After incubation, a clear area of uninterrupted growth underneath and along the side of the test material indicates antibacterial effecttiveness of the fabric.

Finish durability to washing

Hohenstein modified test method – challenge test

Specimens of the test material were shaken in a known concentration of bacterial suspension and the reduction in bacterial activity in standard time is measured. The efficiency of the antimicrobial treatment is determined by comparing the reduction in bacterial concentration of the treated sample with that of control sample expressed as a percentage reduction in standard time.

The finished samples were washed using a standard detergent (2% on weight of fabric) and sodium carbonate (1% on weight of fabric) at 60°C. The antimicrobial activity was assessed after 50 washes by Challenge test.

RESULTS AND DISCUSSION

Antimicrobial activity of Aloe gel treated sample (Agar Diffusion Test)

Figures 1, 2 and 3 shows the result of Agar Diffusion Test for antimicrobial effectiveness against standard test cul-

Table 1. Quantitative analysis test results of treated and untreated sample.

Sino	Bacteria	Finishing agent concentration in gpl	%of bacteria Reduction after treatment
1.	*Staphylococcus*	1	97
		2	97.9
		3	98.1
		4	98.4
		5	99.1

Table 2. Durability of antimicrobial effect of treated sample (5 gpl) after 50 washes.

Sino	Number of washes	Antimicrobial Effect in %
1	10	99.7
2	20	99.3
3	30	99.1
4	40	98.4
5	50	98.0

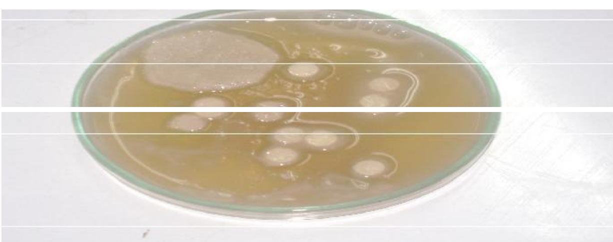

Figure 1. Antimicrobial efficiency of Aloe gel treated sample (Agar Diffusion Test).

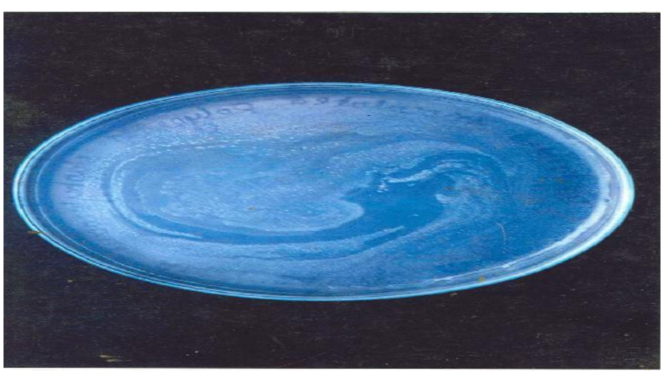

Figure 2. Antimicrobial activity of untreated specimen (Qualitative Analysis Test).

tures viz., *S. aureus* (gram positive) organisms. The zone of bacterial inhibition is indicated by a halo around the specimen. It is apparent that the activity of aloe gel treat ed samples is excellent at 5 gpl for *S. aureus.* It is attribu-

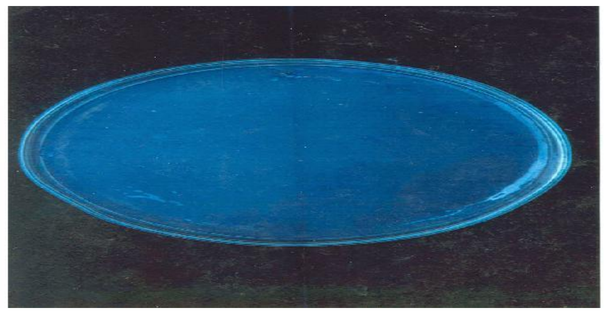

Figure 3. Antimicrobial activity of treated specimen (Qualitative Analysis Test)

buted that bacterial inhibition is due to the slow release of active substances from the fabric surface. It can be seen from the Figure 4 that the amino groups of aloe gel responsible for its excellent antimicrobial activity (Ghannam, 1986). In presence of slight acidity the amino groups will be converted to positive amino group ions will react with the negatively charged protoplasm of microorganisams thus breaking the cell wall and hence destroying the microorganisams (Hecht, 1981).

Anti microbial efficiency of the untreated and treated fabric were performed by the quantitative method. To evaluate the effect of different concentration of anti- microbial activity varied the solution conc. 1, 2, 3, 4 and 5 gpl on weight of fabric. The reduction rates in the number of colonies found on finished samples at different concentrations are given in Figure 5. It can be seen from the Table 1 that the test results were clearly indicated that by increasing the solution concentration the reduction rates of bacteria colonies progressively increased. The fabric exhibited high antimicrobial property at 5 gpl concentration. This is due to that anti microbial agent gets attached to the substrate through bond formation on the surface. The attached antimicrobial agent disrupts the cell membrane of the microbes through the physical and ionic phenomenon (Sarkar et al., 2003). The finishing agent inhibits growth of micro organisms by using an electrochemical mode of action to penetrate and disrupt their cell walls. When the cell walls are penetrated, leakage of metabolites occurs and other cell functions are disabled, thereby preventing the organism from functioning or reproducing.

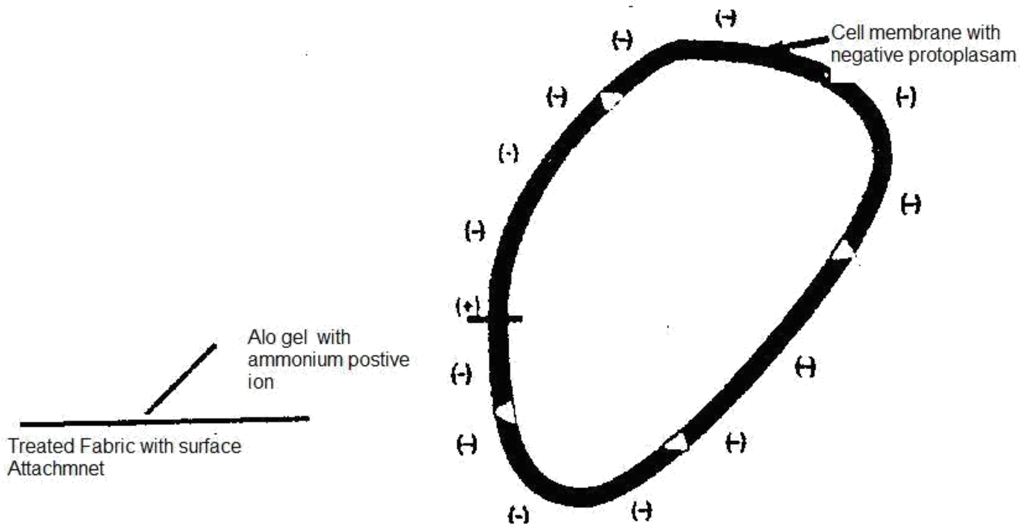

Figure 4. Disturb the cell membrane through physical and Ionic phenomena.

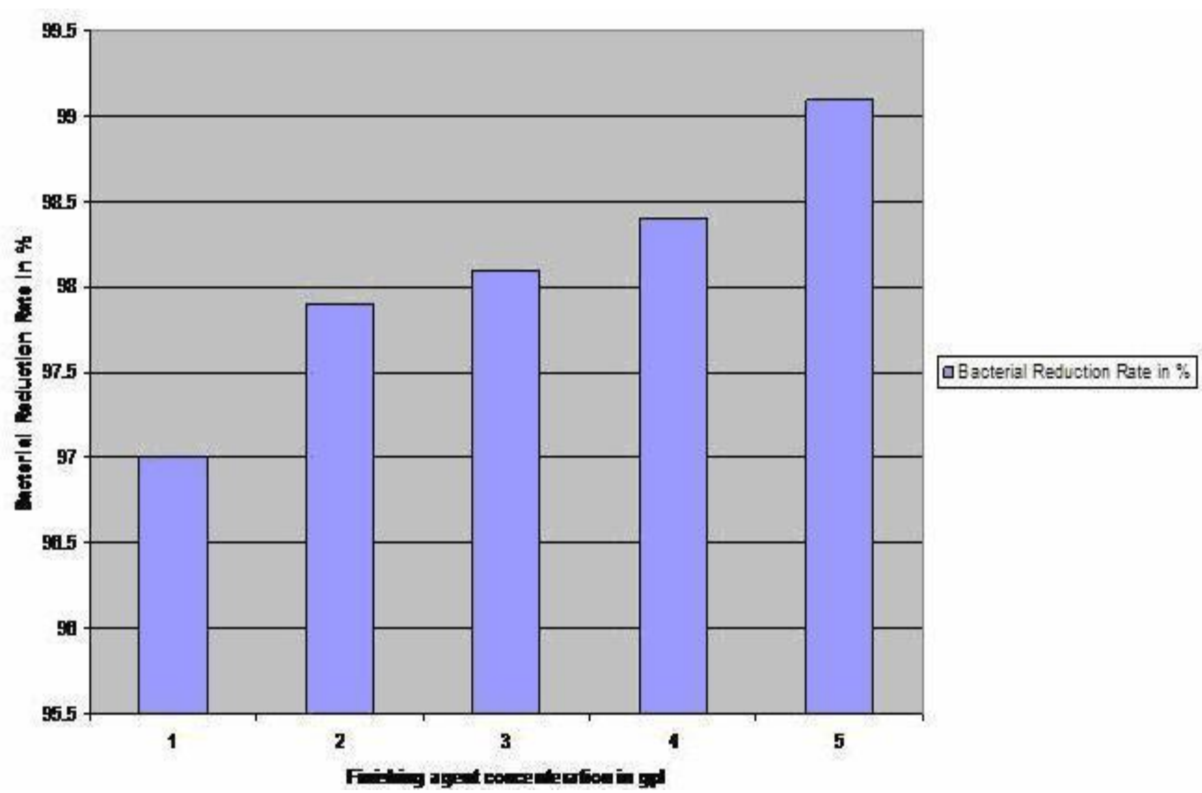

Figure 5. Antimicrobial efficiency of aloe gel treated sample against Staphylococcus aureus (Shake flask Method).

Wash fastness properties of the treated samples

It can be seen from the test results in Table 2 that the wash fastness properties of treated sample during 50 wear wash. The treated fabrics showed good wash fastness as expected. Finishing agent does not migrate off of the treated sample and destroy the bacteria coming in contact with the surface of the treated cloth. The microbes do not consume the antimicrobials, which destroy them by acting on the cell membrane (Odes and Madar Z1991). Hence finishing agents do not lose their effecttiveness and will remain functional throughout the life of

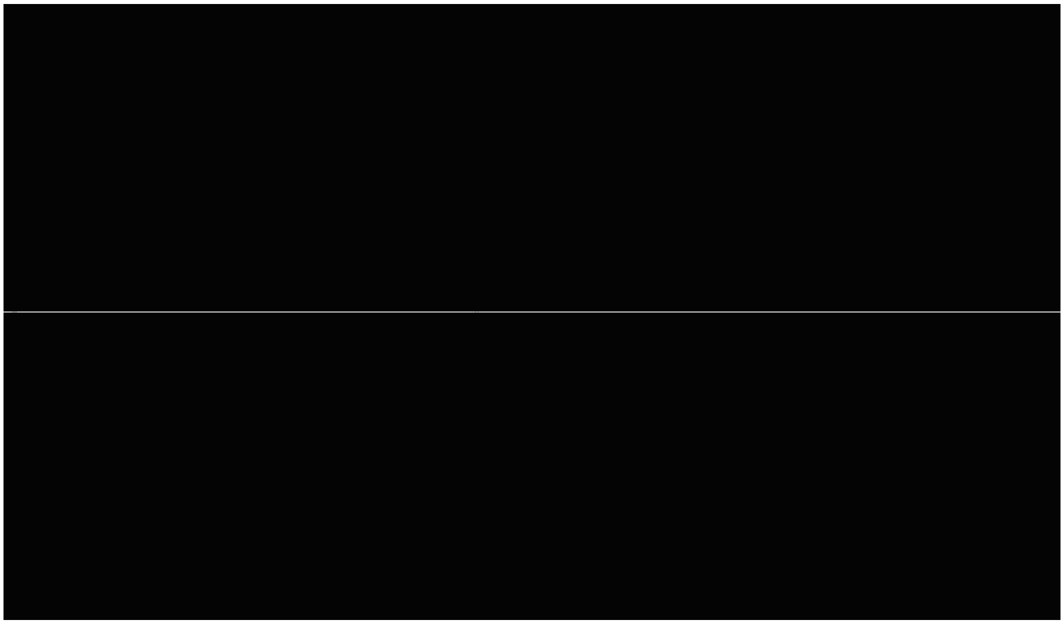

Figure 6. Surface barrier action of the aloe gel treated sample.

the fabric, thus resulting the finish effect will withstand more than 50 washes. Figure 6 clearly indicated that the surface barrier action of the treated sample. The fastness property of the treated sample was excellent. This is due to that antimicrobial agent is not water -soluble, it does not leach out, and it continuously inhibits the growth of bacteria in contact with the surface using barrier or blocking action (Yiai yang, 2000).

Conclusion

The test results are showed that the specimens treated with the solution containing 5 gpl aloe gel showed excellent antimicrobial activity. The treated sample showed high reduction rate in the number of colonies grown and a clear zone of bacteria inhibition.

Finish durability to washing of antimicrobial property of the aloe gel treated sample is 98% after 50 washing. The finding of this study suggests that the treated fabrics can be used for textile application. The results of this study have strong implication for the development of antimicrobial fabrics in Ethiopia.

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