

Evolution of eco-friendly antimicrobial finishes extracted from citrus fruits peel for textile cotton fabric with furtherance domestic washing.

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Abstract— The fabrics and cloths with antibacterial properties are become important to control the infestation by microbes, and to reduce the formation of odor. In order to evaluate washing durability of natural antimicrobial finishes we have used citrus waste extracts from lemon and orange rind. The fabric samples were tested for antimicrobial activity after different washing conditions against bacterial strains by quantitative analysis by AATCC test method 100-2004. The results indicated that the cotton fabric treated with natural finishes shows resistance against microbial strains. The washing process imposed great stresses on the surface of fabric and the antimicrobial activity was gradually decreased after each wash. For analyzing the effect of washing on antimicrobial activity; the finished fabrics were washed several times according to the standard ISO 6330-2012E. The washing result shows a gradual decrease in antimicrobial activity after each wash. The wash-ability of natural finishes was improved with the help of binding agent sodium bicarbonate, which improves the antimicrobial finish attachment with the fabric.

Index Terms— Antimicrobial finishes, Natural extracts, bacterial strains, washing durability,

1 INTRODUCTION

Pakistan is an agriculture country and has increased growth rate of lemon & orange, on seasonal time lot of peel have been generated. ⁽¹⁾ The peel of citrus fruits is a rich source of flavonoid glycosides, coumarins, and sitosterol, glycosides and volatile oils. ⁽²⁾ Many polymethoxylated flavones have several important bioactivities, which are very rare in other plants. ⁽¹⁾⁽²⁾

In textile finishing, perhaps laundry washing is a main problem on laundered fabric when dealing with antimicrobial finishes. Mostly, the applied finishes removed during repeated washing in daily life. ⁽³⁾

Antibacterial fabrics are important not only in medical applications but also in terms of daily human consumption. ⁽⁴⁾⁽⁶⁾ The application of antimicrobial finishes to textiles can prevent bacterial growth and it has become increasingly prominent for hygienic and medical applications. ⁽³⁾

Normally, microbial attacks the textile fibers on the textile products particularly surgical gowns, medical accessories like recovery items and other undergarments and socks etc. These textiles are affected by many kinds of microbes and cause the infection in sector where it is used like hospital, medical institutes & dental clinics. Microbes generate the bacteria, fungi and mildew which nourish the infection by odor, staining & deterioration. ⁽⁵⁾ There ought to be a role of antimicrobial agents or finishes to enhance textiles ability. Antimicrobial finishes were extracted from many sources like natural, synthetic & animals, but for this study the environmental friendly finishes were selected. ⁽⁷⁾

The purpose of the present study was to determine the antimicrobial activity of fabrics functionalized with fruits extract (Lemon, & Orange) during different washing conditions. The Citrus fruits extract is easily available in Pakistan at every season. This study will help not only the washing process but also improves the applications of ecofriendly antimicrobial finishes. With the help of controlled washing process we have tried to investigate the adverse effects of process on durability of antimicrobial finishes. The wash durability of antimicrobial treated fabrics was estimated through AATCC 100- 2004 test method, after being sub-

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jected to several and repeated wash cycles.⁽⁸⁾ For proper washing procedure all test had performed in the view of ISO: 6330.2012E test methods and only cited and verified test detergents taken for research purpose whose used in daily washing.⁽⁹⁾ Figure 2 shows the whole research process overview.

2. MATERIAL & METHODS

The materials used for this research study was 100% cotton bleached fabric, obtained from (Gul Ahmed textile Karachi). The fabrics were passed through rinsing process in a washing machine at 40°C for 45-50 minutes using wetting agent for clean all prior impurities, after that the washed fabric were tumble dried.

The fabric selected for this study was 100 % cotton plain weave and bleached. The weight of the fabric (GSM) was 115.8 g/m². The fruit waste powder (lemon & orange) was dissolved in 100 ml water in 1000 ml measuring cylinder and was shaken continuously for 30 minutes. After 30 minutes it was observed that finish was completely dissolved in water. The volumes of powder vary for research purpose so change in finishing concentration and results. On other for improvement of results we

added the Sodium bicarbonate as a binder which hold the material after several washes and analysis the results on same mention methods. Concentration of binder is not a part of research so it's not mentioning right now. The Table 1 shows the application method of natural finishes on cotton fabric and Figure 1 shows the Preparation status of extract.

In the current study, the antibacterial effect of the fabrics was determined by; AATCC 100-2004⁽⁸⁾ test method was applied for the determination of reduction in bacteria counts quantitatively.

The antimicrobial activity of the finished samples was evaluated after being subjected to several wash cycles by ISO: 6330.2012E⁽⁹⁾



Fig. 1. (a) Fruits waste powder. (b) Mesh powder. (c) Particle size powder.

TABLE - 1

Finishes application parameters for natural fruits extract

Extract source	Finishing	Pickup %	Processing temp & time	
	Concentration%		Drying	Curing
Lemon	1g, 5g, 10g	80	60°C, 10 min	150°C, 3min
Rind	/100 ml			
Orange	1g, 5g, 10g	80	60°C, 10 min	150°C, 3min
Rind	/100 ml			

2.1 AATCC 100-2004 Test Method (Assessment of anti-bacterial finishes on textile material)

Test specimens were cut in 4.8 ±0.1 cm diameter using a steel die. 100µl working culture inoculated test specimens, individually in sterile Petri plates. After inoculation, specimen were placed screw cap jar contained 100ml neutralizing agent (3% Tween 80 and 0.3% lecithin in sterile tap water). The toxicity of neutralizing agent against tested organisms

was reexamined and no toxicity was determined. Jars were shaking vigorously for one minute, serial dilutions were made. From each of three suitable dilutions, 0.1ml liquid was drawn and transferred to TSA.

The number of survivors was determined after 48 hour incubation at 37 ° by counting the colonies as CFU/ml using a colony counter device (Acolyte Super colony Counter, Symbiosis).

Furthermore, additional jars were prepared to

provide information about the bactericidal activity of treatment over contact period (60 minutes).

Percent reduction of bacteria by the specimen treatments was calculated using following formula:

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

Where, **R** is the reduction, **A** is the number of bacteria recovered from the inoculated treated test specimen swatches in the jar incubated over desired contact period. **B** is the number of bacteria recovered from the inoculated treated test specimen swatches in the jar immediately after inoculation.

Swatches of the same fabric construction which containing no antibacterial finish were used as negative control in all experiments

2.3 Domestic Washing Test ISO: 6330–2012E.

The antimicrobial activity of the finished samples was evaluated after being subjected to several wash cycles by ISO: 6330.2012E source of machine is Type A, (Annex B & Annex D) where we selected the procedure No 1B & 5B. Repeat the Domestic washing procedures increase the number of washing. The finished fabrics were washed using Standard detergent.

Use ECE detergent was used with sodium per borate without optical brightener & Enzymes (3% owf) by reference detergent 3 ingredients.

a) Select the programmer for the wash required depending on the type of machine being used. Set domestic washing number, water levels and pull out correct knobs of a (FOM 71S Wascator).

b) Start the machine. When the water is above the base level in the sight tube pour the dissolved powder into the machines by lifting the lid on the top of the machine. Flush down by rinsing the beaker out with an additional quantity of warm water.

c) On completion of the program remove the wash load.

Swatches of the same fabric construction which containing no antibacterial finish were used as negative control in all experiments

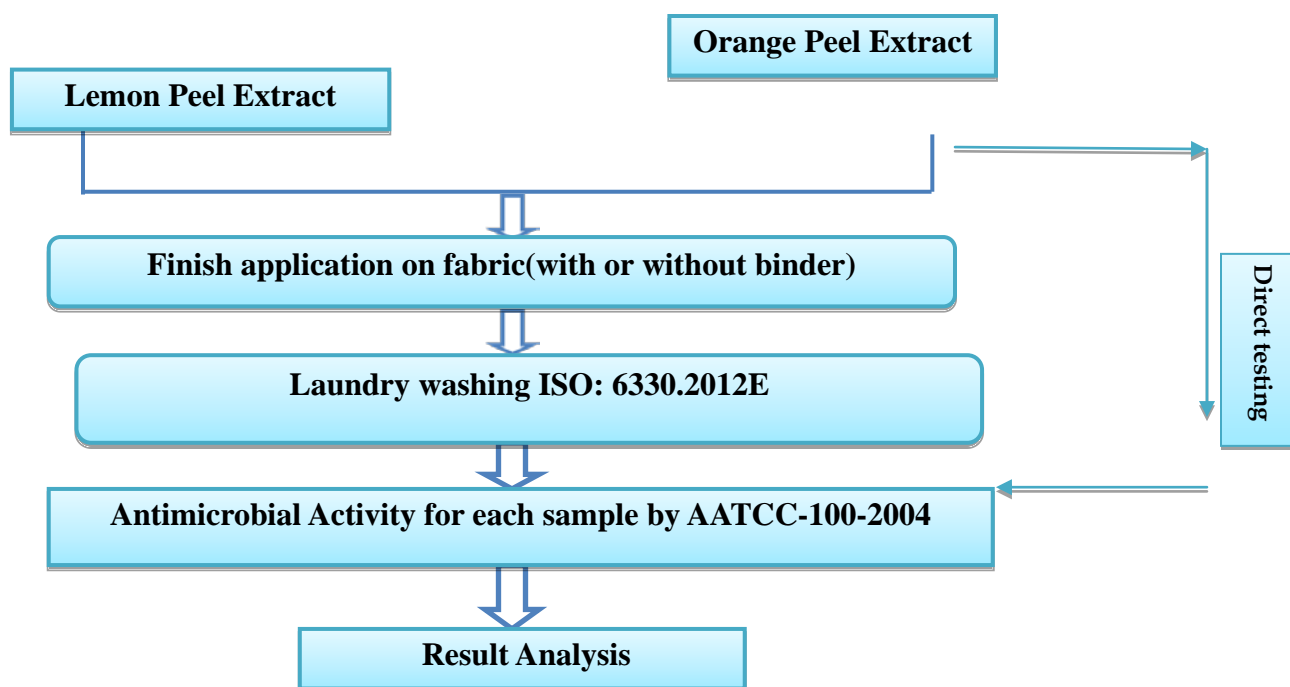


Fig. 2.Schematic Diagram of research methodology

3. Results & Discussion

The antimicrobial activity of the finished samples was evaluated after being subjected to several wash cycles through test method ISO: 6330.2012E. For this study type A machine (FOM 71S Wascator) with 1B & 5B procedure was used as recommended by ISO standard. Same above domestic washing procedures was repeated for each wash. The standard ECE detergent was used with sodium per borate without optical brightener & Enzymes (3% owf)

The table 2 & 3, shows the antimicrobial activity on cotton fabric after subsequent washings. The gram positive and gram negative bacteria behave differently for citrus finishes. Better antimicrobial activity was observed against E. Coli and Staphylococcus with orange peel extracted finishes. When checked the table 2 & 3, it observed that binding agent works well for furtherance of domestic washing against antimicrobial activity. Improvement of results has been achieved by the adding the amount of binding agent. The lowest antimicrobial activity was generated against C. Albian. AATCC- 100-2004 has shown the results in number by colony counting tester for both un-wash & wash sample. The antimicrobial activity of citrus fruit show good

result against microbial reduction for Staphylococcus & E.coli as compared to other two.

The removal of a soil particle from a substrate during laundering involves breaking an adhesive bond between the particle and the fiber. The strength of this bond, and consequently the energy required to detach the particle, depends on the attractive (mainly Van der Waals) forces and the contact area between the soil particle and the fiber surface)

Washing refers to the process of cleaning the surfaces of a solid material by means of a liquid bath involving a physic-chemical action other than simple solution. Generally it is considered to be an unusually enhanced cleaning effect of a liquid bath caused by the Presence of a special agent, the detergent

Water exhibits surface tension at the liquid-air interface and interfacial tension at the liquid-liquid or liquid-solid interfaces. This interfacial tension hinders water from penetrating and wetting textiles. In a body of water the electric forces of attraction (especially hydrogen bonding) operate in all directions and each molecule is held in equilibrium. At the surface of water however, there are no forces acting from the air side and hence the

equilibrium is disturbed. The energy accumulated in the surface molecules of water is manifested as surface tension. As shown in figure 5, the orange extract has excellent antimicrobial properties. Orange extract has shown to potent antimicrobial agents like flavones and many polymethoxylated. The effects of concentration of extracts were analyzed at 1g, 5g and 10g /100ml for both gram positive and gram negative microbes. (Figure 4-5). The best antimicrobial performance was achieved at 10g /100 ml for both natural extracts. This is obvious because of the increased concentrations the active ingredients for each natural extracts were increased. For *Staphylococcus*, *E. coli* and *Bacillus* microbes a gradual decrease was observed in lem-

on and orange extract table 2, 3 & Figure 4-5, (10 g) shows better antimicrobial activity as compared to less concentration (1g). It is mainly due to the presence of alkaloids, which are having antibacterial potential. Anti-microbial performance as we reduce the concentration from 10g to 1 g/ 100 ml. Quinone's, flavonoids, lectines, & polyacetylenes are formed which performed good effect on cotton fabric. In citrus the increased concentration of fruits reach amount of alkaloids and flavonoids which have a large spectrum of biological activity including antibacterial and antifungal for these compositions show the better result against strains in figure-4&5.

TABLE - 2

Antibacterial activity of lemon extract with subsequent

Lemon Extraction Samples (10g/100ml)	No of Washes	AATCC 100-2004(Quantitative)			
		Staphylococcus (Gram Positive) %	C.albicans %	Bacillus (Gram Negative) %	E.Coli (Gram Negative) %
10g/100ml	0	85	8	70	80
10g/100ml	5	71	4	63	74
10g/100ml	10	54	2	47	61
10g/100ml	20	47	0	39	48
10g/100ml(binder)	5	79	4	65	75
10g/100ml(binder)	10	58	2	49	63
10g/100ml(binder)	20	37	0	42	52

TABLE - 3

Antibacterial activity of orange extract with subsequent

Orange Extraction Samples (10g/100ml)	No of Washes	AATCC 100-2004(Quantitative)			
		Staphylococcus (Gram Positive) %	C.albicans %	Bacillus (Gram Negative) %	E.Coli (Gram Negative) %
10g/100ml	0	81	7	68	78
10g/100ml	5	69	4	61	72
10g/100ml	10	51	2	45	51
10g/100ml	20	45	1	38	44
10g/100ml(binder)	5	80	6	63	73
10g/100ml(binder)	10	60	4	51	59
10g/100ml(binder)	20	42	3	41	51

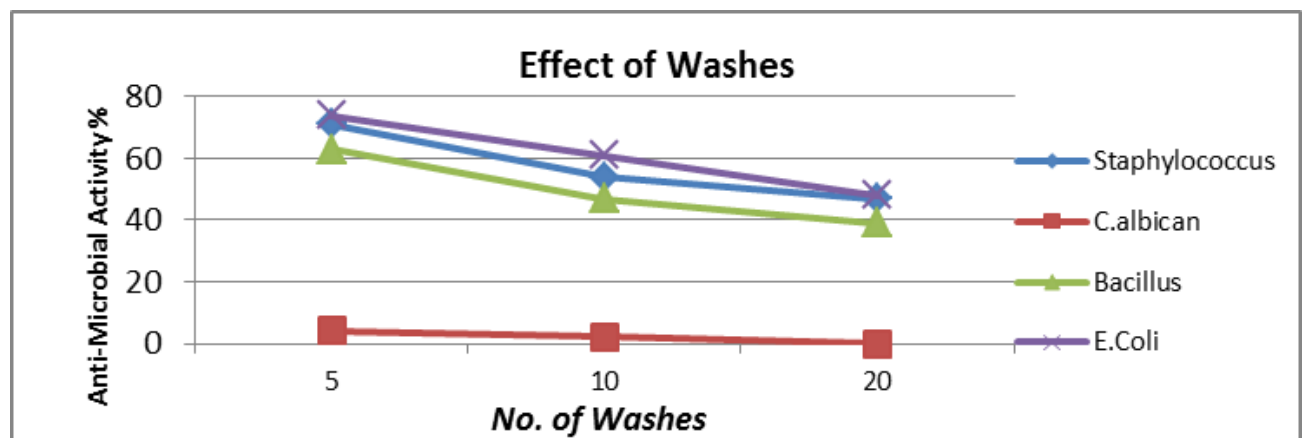


Fig. 3. Effect of number of washes on Antimicrobial Activity of natural finishes

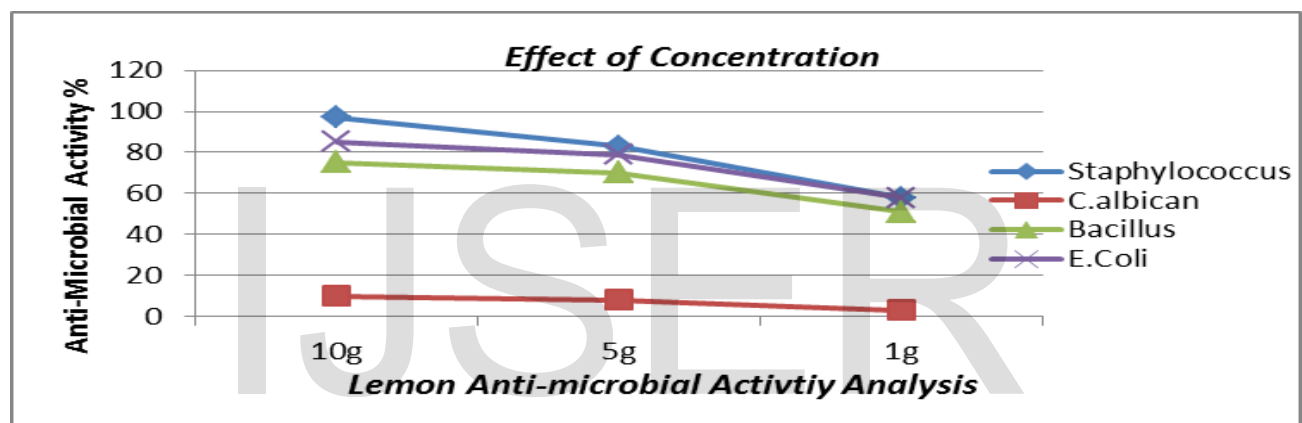


Fig. 4. Performance of natural finishes Lemon Peel against microbial

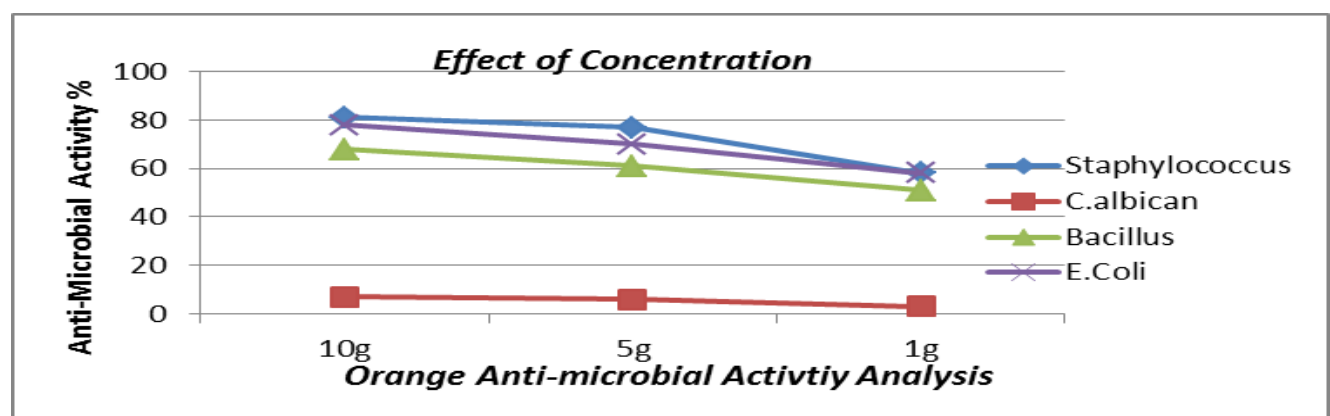


Fig. 5. Performance of natural finishes orange Peel against microbial

CONCLUSION

The coating of cotton fabric using plant natural products was found to exhibit anti-bacterial properties. The fruits rind of citrus fruits as an efficient waste biomass, exhibit efficient anti-microbial agent for the preparation of anti-microbial finish of medical cloths. Lemon & orange natural extract shown better anti-microbial activity against all microbes except *C.albicans*. The washing results show a gradual decrease in anti-microbial activity after each wash. The friction generated during washing caused the removal of active agents to natural extracts. With the help of binders we are able to overcome this obstacle. Binders are the mechanism used to keep the color on the fabric. The choice of binders will always depend upon the final fastness requirements as well as the cost requirements of the process. Almost all the binders used in textile are the addition polymerization products. The binder film in pigment print is a three-dimensional structure, the third dimension is rather less important than the other two. The alkaline cross linking agent proved to be better in performance as compared to the acidic binder with third dimension.

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Industry definition, industry timeline, market dynamics and results analysis

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