

Eco-Friendly Anti-Microbial Textile Finish using Cinnamon Bark (Dalchini) and Garcinia Indica (Kokum)

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Abstract: The inherent properties of the textile fibres provide room for the growth of micro-organisms. There are many anti-bacterial fibres and chemicals available in the market but unfortunately, they are from synthetic base and are not eco-friendly. Consumers in India are taking lead in prompting manufacturers to adopt clean technologies to produce eco-friendly products. Many natural plant products such as extracts from roots, stems, leaves, flowers, fruits and seeds shows anti-microbial properties. In the present study, anti-microbial finish has been imparted to cotton fabric using ethanolic and acetonic extracts of Cinnamon Bark and Garcinia indica by direct application and by microencapsulation. The ethanolic extract was prepared by using 10 gms of herbal material in 100 ml of ethanol and allowed to stand for 24 hours. The acetone extract of the herbs was prepared by refluxing 40gms of each herb in 400 ml of acetone in a Soxhlet extractor. The extracts were applied by directly soaking the fabric in ethanol extract overnight and also by Microencapsulation (for acetone extracts). For microencapsulation, the herbal extract was used as the core material and Gum acacia as the wall material. The treated samples were then tested for their anti-microbial efficiency and also the wash fastness of the finish. It was observed that both the herbal extracts when applied on cotton fabric gives it an excellent anti-microbial property against both gram positive and gram-negative bacteria i.e. *Staphylococcus aureus* and *Klebsiella pneumoniae*. Regarding the wash fastness of the treated samples, it was observed that the finish does not last long. The anti-microbial activity diminishes with every wash and at the end of 5th wash cycle no activity was seen against the selected microbes. However, the limitation of this herbal anti-microbial finish is that it needs to be applied on fabric that is used for disposable products or the products that requires very less washing. The results indicate that the treated fabric is 99.99% anti-microbial and can be used in hygiene products where less washing is required like pillows, curtains, disposable bandages and quilts.

Keywords: Anti-microbial textiles, Cinnamon Bark, Garcinia indica, Microencapsulation.

I. INTRODUCTION

Health and hygiene have always been a major and a primary need of a human life. And this need has moved on in to almost everything that a human comes into contact with, be it food, clothing, environment or surroundings. Consumers are very well versed with the fact that microbes can grow and survive on fabrics also.

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Microbial growth, especially bacteria can result in the deterioration of fabric properties, development of foul smells, skin irritation and cross infections [1].

Textiles with anti-microbial finish not just protect the fabric, but also the user from microbial infestation. Hygiene has become the priority on textiles as they are termed as the ‘second skin’ and are closest to the human body. This aspect calls for the great importance given to anti-microbials in textiles [2].

The inherent properties of the textile fibres provide room for the growth of micro-organisms. Besides, the structure of the substrates and the chemical processes may induce the growth of microbes. Basically, anti-microbial finish is applied to textile material with a view to protect the wearer and the textile substrate itself.

There are many anti-bacterial fibres and chemicals available in the market but unfortunately, they are from synthetic base and are not eco-friendly. Slowly, consumers in India are taking lead in prompting manufacturers to adopt clean technologies to produce eco-friendly products. Many natural plant products such as extracts from roots, stems, leaves, flowers, fruits and seeds shows anti-microbial properties. These extracts can be used for anti-microbial agents for textile finishing in crude form or by microencapsulation to enhance the durability and controlled release of the properties of the extracts [3].

Micro-encapsulation is a process in which small capsules of many useful properties are made by using tiny particles or droplets surrounded by a coating. The material inside the microcapsule is called as the core material whereas the wall is called a shell, coating, or membrane. Usually, microcapsules have diameters between a few micrometres and a few millimetres. The microcapsules can introduce important new qualities to garments and fabrics, such as enhanced stability and the controlled release of active compounds. Microencapsulation is a unique technique which facilitates a controlled release of these properties as and when required and also enhances its durability [4].

In the present work, an eco-friendly fabric finish is developed using herbal plant extract of Cinnamon bark, which is directly applied onto cotton fabric as anti-microbial finishing agent. The microencapsulation of the cinnamon extract is also done and applied on the fabric by pad-dry-cure method with a view to enhance the durability of the finish. The word Cinnamon has its origin from the Greek word **Kinnamomon**. Cinnamon is a spice and is obtained from the inner bark of several trees from the genus *Cinnamomum*, which is used in the preparation of sweet as well as savory foods. There are four main varieties of cinnamon, Ceylon cinnamon (*Cinnamomum zeylanicum*), and Cassia cinnamon (*Cinnamomum cassia*).

The spice is also known for its aromatic fragrance and sweet, warm taste. It is derived from the bark of a tree, belonging to the family Lauraceae [5]. Having known for its great medicinal values, it is **Anti-fungal**[6]-[9], **Anti-bacterial**[6],[10]-[13], **Anti-viral, Anti-parasitic and Anti-septic**[14].

Garcinia indica is a plant from mangosteen family and is commonly known as 'Kokum'. It can be easily found in almost all kitchens of India. There is a vast use of the fruit of Garcinia indica as remedial medicine in Indian system of medicine for treating various ailments [15]. It is a rich source of bioactive molecules including Xanthones, Flavonoids, Benzophenones, Lactones and Phenolic acids [16].

Kokum contains the following phytonutrients: Anthocyanins (Cyanidin-3-sambubioside, Cyanidin-3-glucoside); Kokum butter; Hydroxycitric acid (HCA) and Garcinol. Anthocyanins are well known for their antioxidant, anti-inflammatory and anti-carcinogenic activity. Hydroxycitric acid (HCA) plays an important role in fat/lipid metabolism [17].

It is traditionally used to treat sores, skin ailments such as rashes caused by allergies, dermatitis and chaffed skin, burns, scalds, and to relieve sunstroke [18].

The active ingredient found in Garcinia indica extract is 'Garcinol', which is a polyisoprenylated benzophenone compound and responsible for most of the observed biological activities of this herb. Garcinol is an example of prenylated chalcone, which a numerous beneficial effects on human health and diseases [19],[20].

Table- I: Constituents of Cinnamon[5]

Bark	Cinnamaldehyde – 65 to 80% Eugenol – 5 to 10%
Leaves	Cinnamaldehyde – 1 to 5% Eugenol – 70 to 95%
Root Bark	Camphor – 60%
Fruit	Trans – cinnamyl acetate and β – caryophyllene
Cinnamomumzeylanicum buds	Terpene hydrocarbons - 78% Alpha Bergamotene - 27.38% Alpha - Copane - 23.05% Oxygenated terpenoids - 9%
Cinnamomumzeylanicum flowers	(E)-Cinnamyl acetate - 41.98% Trans-alphabergamotene - 7.97% Caryophyllene oxide - 7.2%

The two major constituents of cinnamon bark are Cinnamaldehyde 65-80% & Eugenol 5-10%. Other compounds which are present in lesser percentages those are Cinnamic acid, Hydroxyl Cinnamaldehyde, Cinnamyl alcohol, Coumarin, Cinnamyl acetate, Borneol etc [5].

II. MATERIALS AND METHODS

Cinnamon bark and Kokum were procured from the local market of Mumbai. Scoured and bleached 100% cotton fabric was purchased from the local market and used for the application of anti-microbial finish.

A. Preparation Of Herbal Extract

The Kokum is wet but Cinnamon bark is already in a dried state. Both the ingredients were grounded into powder and then used for extraction. The kokum powder was dried in an oven at temperature between 60°C-80°C for 6-8 hours. The extraction was carried out in two procedures and by two mediums, which included preparation of Acetonic

extract by Soxhlet extractor and the Ethanolic extract by the separation of active substances.

Ethanolic Extraction

The cinnamon bark and Kokum were grinded and made into fine powder using an electric grinder and after grinding kokum was dried in an oven. The powdered material was extracted with ethanol by adding 10 gms of cinnamon powder and Kokum each in 100 ml of ethanol for 24 hour to separate the active ingredients.

Acetonic Extraction

Each 40 gm of the powdered Cinnamon bark and Kokum was refluxed in a Soxhlet apparatus in 400 ml of acetone till the completion of 3 extraction cycles. The prepared extract was then cooled off and used for further procedures.

B. Fabric Treatment With Herbal Products

The fabric was prepared for the application of finish by washing it in a standard soap solution and boiling it for around 15 minutes. The dried fabric was then equally divided for Direct application and Microencapsulation.

C. Direct Application Method

10 grams of the cinnamon powder and Kokum powder was mixed in 100 ml of ethanol each in a beaker and was left for 24 hours to separate the active ingredients. The herbal mixtures were then stirred and filtered through a filter paper. For each 100 ml of extract thus obtained, 6 grams of citric acid was added and dissolved by continuous stirring as a cross linking agent. Two small pieces of the cotton fabric were then soaked in each of the containers having the extracts and kept in a warm water bath for about 5 minutes. Then the samples were allowed to soak in the extract overnight. It was then taken out and dried.

D. Microencapsulation

For microencapsulation, 20 grams of sodium sulphate was dissolved in 100 ml of water. Then 6 grams of citric acid (cross linking acid) was added and dissolved by continuous stirring. Then in a different beaker, 10 gram of gum acacia was added in 100 ml of water and stirred. It was allowed to swell for atleast 15 minutes. 50 ml of hot water was added in the gum acacia solution and was stirred continuously. The temperature was maintained at 40°C to 50°C. In the next step, 1.5 grams of herbal extract was added dropwise in stirring condition in the acacia solution and stirring was continued for next 15 minutes. Then 10 ml of 20% sodium sulphate solution was added and stirred and again 6 grams of citric acid was added and stirred. Thus, the solution for microencapsulation was prepared and freezed overnight so that the capsules can be formed. This procedure was performed for both cinnamon and kokum extracts separately.

E. Padding And Curing

After the solution for microencapsulation was prepared, the cotton fabric samples were dipped in the solution and allowed to stay for 15 minutes. Both the fabrics were then padded through a pneumatic padding mangle.

The treated fabrics were then air dried a little and cured at 110°C for 1 minute.

F. Assessment Of Anti-Microbial Activity

The treated fabrics were then assessed for anti-microbial activity through AATCC 147-2011 method and the test organisms to be tested were

- *Staphylococcus aureus* ATCC 6538
- *Klebsiella pneumonia* ATCC 4352

Table- II: Assessment of anti-microbial activity of the treated samples

Sample	Test Organisms	No. of bacteria per sample		Percentage reduction
		'0' hours (B)	'24' hours (A)	
Direct Application Cinnamon treated sample	<i>Staph. aureus.</i>	1.57×10^5	<10	99.99 %
	<i>K. pneumoniae</i>	1.88×10^5	<10	99.99 %
Direct Application Garcinia indica treated sample	<i>Staph. aureus.</i>	1.38×10^5	<10	99.99 %
	<i>K. pneumoniae</i>	1.44×10^5	<10	99.99 %
Control Sample	<i>Staph. aureus.</i>	1.36×10^5	1.45×10^7	Nil
	<i>K. pneumoniae</i>	1.35×10^5	1.26×10^7	Nil
Microencapsulation done with Cinnamon	<i>Staph. aureus.</i>	1.57×10^5	<10	99.99 %
	<i>K. pneumoniae</i>	1.88×10^5	<10	99.99 %
Microencapsulation done with Garcinia indica	<i>Staph. aureus.</i>	1.38×10^5	<10	99.99 %
	<i>K. pneumoniae</i>	1.44×10^5	<10	99.99 %
Control Sample	<i>Staph. aureus.</i>	1.36×10^5	1.45×10^7	Nil
	<i>K. pneumoniae</i>	1.35×10^5	1.26×10^7	Nil

G. Wash Durability Of The Treated Fabric

Wash durability of the fabrics was tested through standard procedure after one and five washes and the samples were assessed for their anti-microbial activity. It was observed that the treated samples displayed good anti-microbial activity after one wash but the activity started to reduce after every wash and there was no anti-microbial activity recorded after the fifth wash.

Table- III: Quantitative anti-microbial analysis (AATCC 100 2012) of wash fastness of the treated samples after 1 wash

Samples	Average count of <i>Staphylococcus aureus</i> (cfu/ml)		% Reduction	Average count of <i>Klebsiella pneumoniae</i> (cfu/ml)		% Reduction
	0 hr	24 hr		0 hr	24 hr	
Cinnamon extract Direct Application	2.8×10^4	2.5×10^3	91.1	1.1×10^5	1.7×10^4	87.9
Garcinia indica extract Direct Application	1.2×10^4	8.0×10^3	93.3	1.2×10^5	1.6×10^4	0
Cinnamon extract Microencapsulation Application	1.5×10^4	2.7×10^3	98.2	1.2×10^5	1.6×10^4	86.7
Garcinia indica extract Microencapsulation Application	3.0×10^4	1.0×10^3	99.7	1.2×10^5	0	100

Table- IV: Quantitative anti-microbial analysis (AATCC 100-2012) of wash fastness of the treated samples after 5 washes

Samples	Average count of <i>Staphylococcus aureus</i> (cfu/ml)		% Reduction	Average count of <i>Klebsiella pneumoniae</i> (cfu/ml)		% Reduction
	0 hr	24 hr		0 hr	24 hr	
Dalchini Direct Application	1.8×10^5	1.5×10^8	0	1.8×10^5	1.8×10^9	0
Garcinia indica Direct Application	1.8×10^5	2.5×10^8	0	1.6×10^5	2.8×10^9	0
Dalchini Microencapsulation Application	1.3×10^5	8.0×10^9	0	3.2×10^5	3.6×10^9	0
Garcinia indica Microencapsulation Application	2.3×10^5	6.0×10^9	0	3.2×10^5	4.7×10^9	0

III. RESULTS AND DISCUSSIONS

In the above study, an effort has been made to develop an eco-friendly herbal finish that can be applied to cotton fabrics to incorporate anti-microbial activities to the fabric. For this purpose, the herbal material selected to fulfill the objective are Cinnamon and Garcinia indica (Kokum) which are known for their medicinal properties and are available in almost every Indian kitchen.

Cinnamon and Garcinia indica were used to prepare extracts and these extracts were then used to finish the cotton fabric samples through Direct application and Microencapsulation. The samples were then tested for their anti-microbial activity and wash fastness. The results thus obtained indicate that both the extracts when applied on cotton fabric displays excellent anti-microbial activity against both *Staphylococcus aureus* and *Klebsiella pneumoniae*. The treated samples showed 99.99% anti-microbial activity against both the stains as compared to the control sample that showed no activity. However, no difference in the activity displayed was observed with respect to the different application procedures that is Direct application and Microencapsulation.

Regarding the wash fastness of the treated samples, it was observed that the finish does not last long. It was observed that the anti-microbial activity diminishes with every wash and at the end of 5th wash cycle no activity was seen against the selected microbes. The direct application method of Cinnamon extract, makes the treated fabric 91.1% anti-microbial efficient against *Staphylococcus aureus* and 87.9% against *Klebsiella pneumoniae*. Whereas on the other hand, the direct application method of Garcinia indica on the cotton fabric makes the fabric 93.3% anti-microbial efficient against *Staphylococcus aureus* and to be noted; no anti-microbial activity was observed against *Klebsiella pneumoniae* through this method of application.

The microencapsulation method of application of extracts displayed following results: the microencapsulated Cinnamon extract treated samples showed 98.2% anti-microbial efficacy against *Staphylococcus aureus* and 86.7% against *Klebsiella pneumoniae*.



On the other hand, the microencapsulated *Garcinia indica* extracts treated fabrics showed excellent anti-microbial efficacy that comes to 99.7% for *Staphylococcus aureus* and 100% anti-microbial efficient for *Klebsiella pneumoniae*. Therefore, it can be said that both the herbal extracts when applied on cotton fabric gives it a good anti-microbial property.

IV. CONCLUSION

It should be pointed out that this herbal finish does not come out to be durable as it lasts only up to a few washes. Although, the efficacy of the anti-microbial property remains unchanged or mildly changed after one wash but diminishes after few more washes. Therefore, this finish marks its usage with a limitation to be applied on fabric that is used for disposable products or the products that require very less washing. These products can be identified in the field of hygiene and personal care. The results indicate that the treated fabric is 99.99% anti-microbial and can be used in hygiene products where less washing is required like pillows, curtains, disposable bandages and quilts.

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AUTHORS PROFILE



Khushboo Shrimali is a research scholar from S.N.D.T University Mumbai; Department of Textile Science and Apparel Designing. She has been working in the field of providing herbal anti-microbial finishes to cotton fabrics with regards to the eco-friendly processing of textiles. She is a member of Indian Fiber Society and has presented papers and posters in many National and International conferences. She believes in promoting the "GO GREEN" drive and thus would like to use her research in developing baby hygiene products that are eco-friendly.



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