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JTATM Journal of Textile and Apparel, Technology and Management

Volume 9, Issue 1, Fall2014

Effect of Antimicrobial Finish on Odor Control Properties of Apparel Fabric

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ABSTRACT

In this research an attempt has been made to reduce the odor formation in textile material with the help of Terminalia chebula finish. Knitted cotton textile materials with different structures were used for in-vivo analysis. The initial study shows that, the odor formation in textile material is strongly correlated with the thickness and mass per square meter. The odor analysis was repeated after the Terminalia chebula extract finishing. The subjective analysis results of treated fabric shows significantly lower odor intensity after in-vivo study. In the finished textile, rib structure with high thickness and mass possessed low odor than single jersey. Further it is also confirmed the bacterial reduction in the axilla worn material objectively. The bacterial isolation was performed and count was analyzed and the results shows a significant reduction in bacterial percentage. The test results on the effectiveness of Terminalia chebula treatment against the odor causing bacterial strains like Staphylococcus aureus (MTCC 737), Corynebacterium Sp (MTCC 8730), Corynebacterium Sp (ATCC 3021), B. licheniformis (MTCC 429), M. luteus (ATCC 49732), Corynebecteriurn acnes (MTCC1951), Pseudomonas Sp.,(MTCC 6628), Escherichia coli (MTCC 1687), shows that there is a maximum bacterial reduction in terms of zone of inhibition up to 42 mm. The FTIR studies confirm the presence of active substance like tannins, phenols and saponins on the finished fabric, which in turns inhibiting odor formation. Hence, this study suggests an alternative and eco-friendly way of finishing in textile material against odor propagation and retention.

Keywords: Axillary odor, Subjective study, Terminalia chebula, Anti-bacterial test, odor reduction, FTIR analysis

Introduction

It is well known that axillary micro flora play very important roles in human odor production. Research into the nature of body odor began in the 1960s with the discovery that axillary odor could be produced by the interaction of odorless apocrine secretions with inoculation by gram-positive organisms found on the skin surface[1]. The reason for the body odor formation is because of the skin and their biotransformation of sweat components secreted in the human axillae[2]. The moist environment of the human axilla is characterized by the presence of oily and odorless fluids containing proteins, cholesterol, steroid derivatives, squalene and a wide range of lipids[3].

These substances are secreted by eccrine, sebaceous and apocrine glands specifically located in the underarm region of the human body and some of which are stimulated by emotional stress[4]. Emotional sweating does not occur until puberty and is often associated with development of strong body odour[5]. Dravnieks et al.[6] referred to primary odor (originating in the axilla itself) and secondary odor (developing in garments in contact with the axilla), stating that the secondary site differs from the axilla in humidity, temperature, airflow, nutrients and presence of antimicrobial agents. During the physical activity, the textile fabrics have an effect on sweating and odor formation. The poor material selection according to the requirements is one of the reasons for odor formation[7]. Sweat secretion, the bacteria population and a moist environment are the three major Components contributing to odor production by the skin[8]. The bacteria flora of the skin varies within broad limits both qualitatively and quantitatively. The relationships between the bacteria population, the host, and the Environment have already been described elsewhere[9]. All these three factors majorly influenced by the textile material which is worn very next to the human body parts like axilla, foot and etc.

However there are very few studies explains the inter relationship of the textile material and their importance in odor formation[10-12]. Generally, textiles are an excellent substrate for microbial growth, because they are made of organic materials providing a good base for biofilm attachment and the human sweat, which is retained by the textiles, provides nutrients necessary for bacterial growth[13]. Most ideal growth conditions occur at high moisture, which is normally found under increased production of sweat. In extreme cases, microorganisms can cause serious problems, include fabric rotting, staining, unpleasant odors and health concerns ranging from simple discomfort to physical irritation, allergic sensitization, toxic responses, infection and disease[14].

But the odor formation cannot be avoided and hence, the textiles, treated with Antibacterial agents, have been developed, with the aim of reducing odor by decreasing the number of bacteria on the skin. *Terminalia chebula* is an important medicinal plant in Indian traditional medicine and it is most frequently used herb in Ayurveda. *Terminalia chebula* is a medium- to large-sized tree distributed throughout tropical and sub-tropical Asia, including China and Tibet. This tree is found in the forests of northern India, Uttar Pradesh and Bengal, and is common in Tamil Nadu, Karnataka and southern Maharastra.

Terminalia chebula is routinely used as traditional medicine by tribal of Tamil Nadu in India to cure several ailments such as fever, cough, diarrhea, gastroenteritis, skin diseases, candidiasis, urinary tract infection and wound infections[15]. Antibacterial activity of *Terminalia chebula* extracts against several bacterial strains have been reported[16]. We have recently reported that, the methanol extract of *Terminalia chebula* on textile material effectively in healthcare and hygienic sector. We also reported that, the potentiality of the abovementioned herbal material against the wide spectrum of human pathogenic bacterial strain[17-19]. Hence, this research attempts to study the effect of *Terminalia chebula* treatment on fabric for axilla odor reduction. The *in vivo* measurements have been done after wear trial and also the percentage reduction of bacteria were identified by bacterial isolation process. The effectiveness of antibacterial agent with respect to the real time situation was obtained in terms of odor reduction and bacterial population reduction against the odor causing bacteria.

MATERIALS AND METHOD

Sample selection and preparation

Commercially available knitted cotton fabric in three basic structures Plain, Rib and Interlock fabrics commonly used for men's vests were purchased. The purchased fabric were laundered and laid flat to dry

prior to cutting specimens. Fabric specimens were (225mm X 225 mm) cut from the prepared fabric and edges over locked. The fabric specimens were fixed to the underarm area of the 100% cotton vests. So the center of the fabric specimen was close to axilla when the vest is worn by the wearer[10].

Table 1. Fabric Specification detail

S.No	Fabric code	Fabric structure	Wales/Inch	Courses/Inch	Mass g/m^2	Thickness in mm
1	a	Single Jersey	40	54	145	0.42
2	b	1 X 1 Rib	36	24	325	1.22
3	c	Interlock	46	36	157	0.64

Wear trial and orientation of the subjects

The orientation phase of the subject was adapted from McQueen at al.,[10]. The subjects were selected in the age group of 27- 35. Five male participants involved in non-sedentary jobs and five male participants involved in sedentary jobs were selected. Before the experimental study, the subjects were advised not to use any cosmetic, deodorants and any other antibacterial products. They were advised to follow few conditions for 7 days as conditioning phase. Further they were also advised not to consume any spicy foods 48 hours before the experiment[11]. The normal working hours (8 hours) were allotted for each subject. The subjects were also advised to wear the same fabric specimen for two days consecutively. After the trial phase the samples were separated and put into an air tight poly bags, with the details of the sample and fabric used. These samples were used for the analysis.

Subjective Analysis

The odor test is performed with reference to SNV 195651[20]. The test specimen (40g) is placed on top of 300ml sodium carbonate solution and kept in a closed container. The container is put into an oven set to a temperature of 37 +/-2°C for 15 hours.

Six people (minimum) are required to independently judge the odor intensity and rate it according to the following nomenclature

Intensity Scales

Grade 1 – odorless
Grade 2 – weak odor
Grade 3 – tolerable odor
Grade 4 – annoying odor
Grade 5 – intolerable odor

The mean value of the grades for the odor intensity must be a grade < 4.

Bacterial Isolation from the worn cotton sample

The test samples were collected aseptically and stored in air tight pouches. A part of the sample was taken and allowed to grow in Tryptic soy broth. In a test tube 10 ml of sterile Tryptic soy broth was taken and test fabric sample was kept in the broth. Then the broth was incubated at 37°C for a time period of 24-48 hours. After incubation the broth becomes turbid due to the presence of bacterial strains present in the test fabric. The broth may constitute more than one species of bacterial strain[21].

The bacterial isolation procedure was carried out by the Gram staining[22-23], Catalase test[24], Biochemical Test[25], Citrate Utilisation[26, 27] test methods.

Herbal Extract preparation and application

Terminalia chebula fruits, chosen for this study were purchased from the

commercial outlets of the Coimbatore District, Tamilnadu, India. The collected quantities of *Terminalia chebula* fruits were shade dried and powdered. The methanol extract of the powder was obtained. 10000 mg of powder was soaked in 100 ml of methanol separately for 24 hours to obtain 10% concentrated solution; the active substances were dissolved in methanol. The extract was filtered and used for antimicrobial finishing Knitted cotton fabric with three structures namely plain, Rib and Interlock, scoured and bleached prior to the application of the antimicrobial finish. The methanol extracts of *Terminalia chebula* were used for the cotton fabric by dipping in the bath with material to liquor ratio of 1:10 and then pad-dry-cured at 100^0C.

CHARECTERISATION

Scanning electron microscopy analysis

The scanning electron microscopy (SEM) technique was used to assess the surface morphology of treated and untreated fabric.

FTIR Analysis

The samples were analyzed for FT-IR spectra with a SHIMADZU Spectrophotometer to identify the presence of substance in the fabric. The spectra were obtained in the range of 400-4000 cm-1.

Antibacterial Analysis (AATCC 147-2004)

The treated and untreated fabric samples were placed in the AATCC bacteriostasis agar[28], which has been previously inoculated (Mat culture) with a test organism. After incubation, a clear area of uninterrupted growth underneath and along the side of the test material indicates the antibacterial effectiveness of the fabric. The area of the inhibition zone is a measure of antibacterial effectiveness of the material. The bacterial growth on the treated fabric was analyzed with the help of atomic force microscope.

Statistical Analysis

The mean of subjective analysis of odor intensity was calculated and ANOVA carried out to analyze the effect of fabric structure on odor intensity. The analysis of variance was performed to study the effect of bacterial counts on the structure, participant. The correlation analysis was performed to analysis the inter dependence between the factors. Both the analysis were performed by using data analysis feature in Microsoft excel software.

RESULTS AND DISCUSSION

Effect of Fabric Structure on Odor Intensity – Subjective Analyze.

The subjective analysis was performed as per SNV 195651. The subjective analysis results reveals that the average odor intensity observed was high in the rib fabric followed by interlock fabric and is higher than plain fabric ($p<0.05$). Since all the fabrics selected were of similar fiber content (cotton) with different in structure (as in Table 1), the differences may results because of the structural changes like thickness and mass per area.

This difference in odor intensity may be because of the easy evaporation of sweat in lighter fabric due to their easy transmission than interlock and 1X1 rib. The heat and water vapor resistance increases with the increment of material thickness and air entrapped in the fabric[29,30] mentioned that. Interlock fabrics with the highest thermal absorptivity values, gave the coolest feeling at the beginning of skin contact. This situation is explained by the construction of the fabric surface.

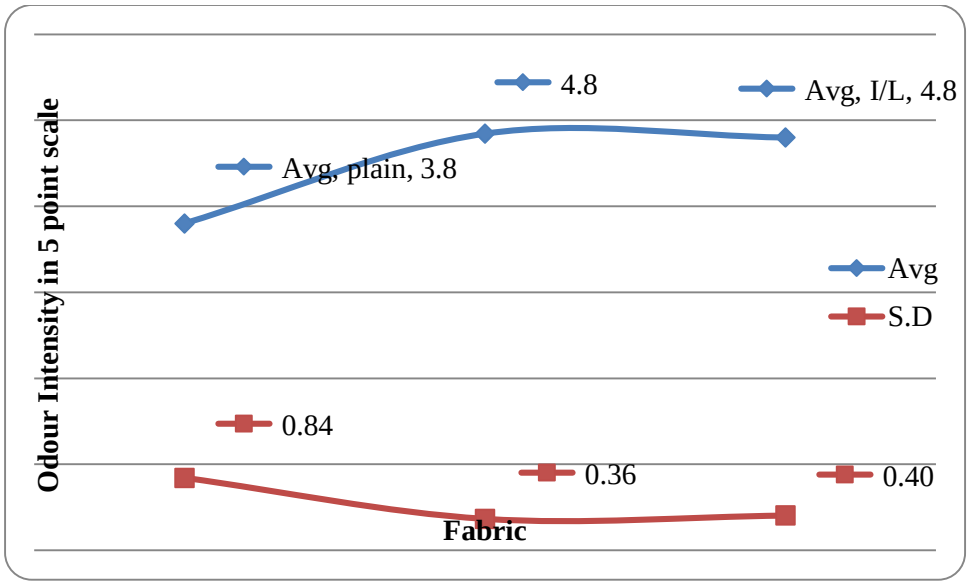

Figure 1. Average rating for different structures along with standard deviation

Thermal resistance is a measure of the body's ability to prevent heat from flowing through it. Generally increment in fabric thickness increases the thermal resistance. The cotton fabric sample gave the lowest thermal resistance values for the single jersey structure, and the greatest values were obtained for the interlock structure.

Bacterial Isolation and Odor Analysis

The bacterial isolation tests were performed for all participants on both the axilla. The day to day variations were insignificant. Hence in this study the aforementioned factors were ignored and the analysis was performed invariantly. However, Differences among participants were expected, as the type and number of bacteria is highly variable among individuals[31].

The results from bacterial isolation process of worn samples indicate that, all the samples worn at axilla region consisted of *Bacillus* Sp., along with *corynebacterium* Sp., Other than this there are many *Staphylococcus* Sp., *Enterococci* Sp., *E.coli*, and *Pseudomonas* Sp., found in the axilla region in line with Kloos, & Musselwhite[32], These microorganisms generate a variety of odoriferous compounds that characterize the axillary region. In vivo correlations of odor quality and axillary bacterial populations demonstrated elsewhere[31].

The bacterial isolation process result reveals that, the fabrics mostly consist of *corynebacterium* Sp, *Bacillus* Sp., *Pseudomonas* Sp., and *Staphylococcus* Sp., for all structures invariantly. The findings of the previous research reveals that, the metabolic byproduct of the bacterial species are various odoriferous compounds based on their species type. They have also mentioned various carboxilic acids produced by the metabolic reactions of the bacterial strains[33]. It can be under stood that, the presence of *corynebacterium* Sp, *Bacillus* Sp., *Pseudomonas* Sp., and *Staphylococcus* Sp in the axilla region in turns produces propionic acid, amino acids**,** butyric acid, acetic acid and valeric acid as they multiply. *Corynebacterium* Sp, is one of the most found isolate in human skin, in specific to the axilla region[34]. The presence of acetate, formate and Succinate compounds in the axilla region due to the metabolic by product of *corynebacterium* Sp., is the major cause for odor formation[35]. Next to the *corynebacterium* Sp, and *Bacillus* Sp., *Staphylococcus* Sp., is found in axilla region, these findings are in line with Taylor et al[34]. The presence of the *Staphylococcus* Sp., generates the acetate and carbohydrate sources which results in malodor formation.

CHARECTERISATION OF HERBAL FINISHED TEXTILE

SEM Analysis

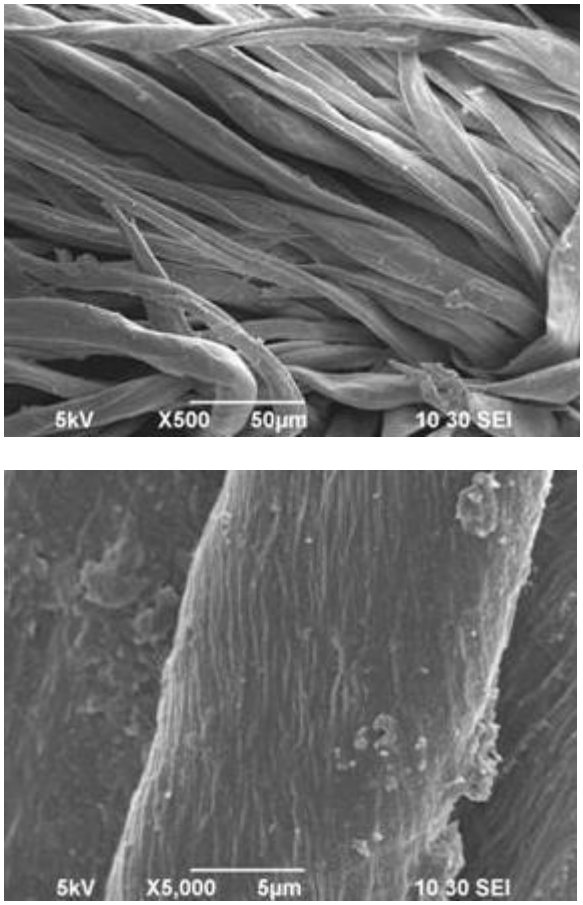

Figure 2. SEM analysis of Herbal extract treated knitted structures

The herbal treated fabrics were analyzed for the presence of herbal material on the fabric surface using scanning electron microscope (SEM). The magnification at 2000X shows the clear indication of surface deposition. The add-on percentage of the extract on the finished fabric is 6.66 %, 8.33% and 10.9% respectively for single jersey, interlock and rib. However the treatment of the fabric carried out in simple pad-dry-cure method, the uniformity level and the distribution of the extract throughout the processing area need to be studied separately.

FTIR analysis of finished fabric

In *Terminalia chebula*, 33% of the total phytoconstituents are hydrolysable tannins (which may vary from 20-50%) and are responsible for pharmacological activity. These tannins contain phenolic carboxylic acid like gallic acid, ellagic acid, chebulic acid and gallotannins. Ellagitannin such as punacalagin, casurarinin, corilagin and terchebulin and others such as chebulanin, neochebulinic acid, chebulagic acid and chebulinic acid reported in literature[36,37].

The tannin content varies with the geological variation. Flavonol glycosides, triterpenoids, coumarin conjugated with gallic acid called chebulin, as well as phenolic compounds were also isolated from terminalia chebula[38]. Total eight compounds viz. gallic acid, methyl gallate, ethyl gallate, chebulagic acid, tetra-*O*-galloyl-*β*-D-glucose, ellagic acid, chebulinic acid and penta-*O* galloyl-*β*-D-glucose from *Terminalia chebula* were isolated on reverse phase chromatography[39].

Several researchers identified the content of *Terminalia chebula* by phytochemical analysis and they have reported that the major constitutions of *Terminalia chebula* are alkaloid, Flavonoids, Tannins, Glucosites, phenolic and Saponin compounds[40, 41].

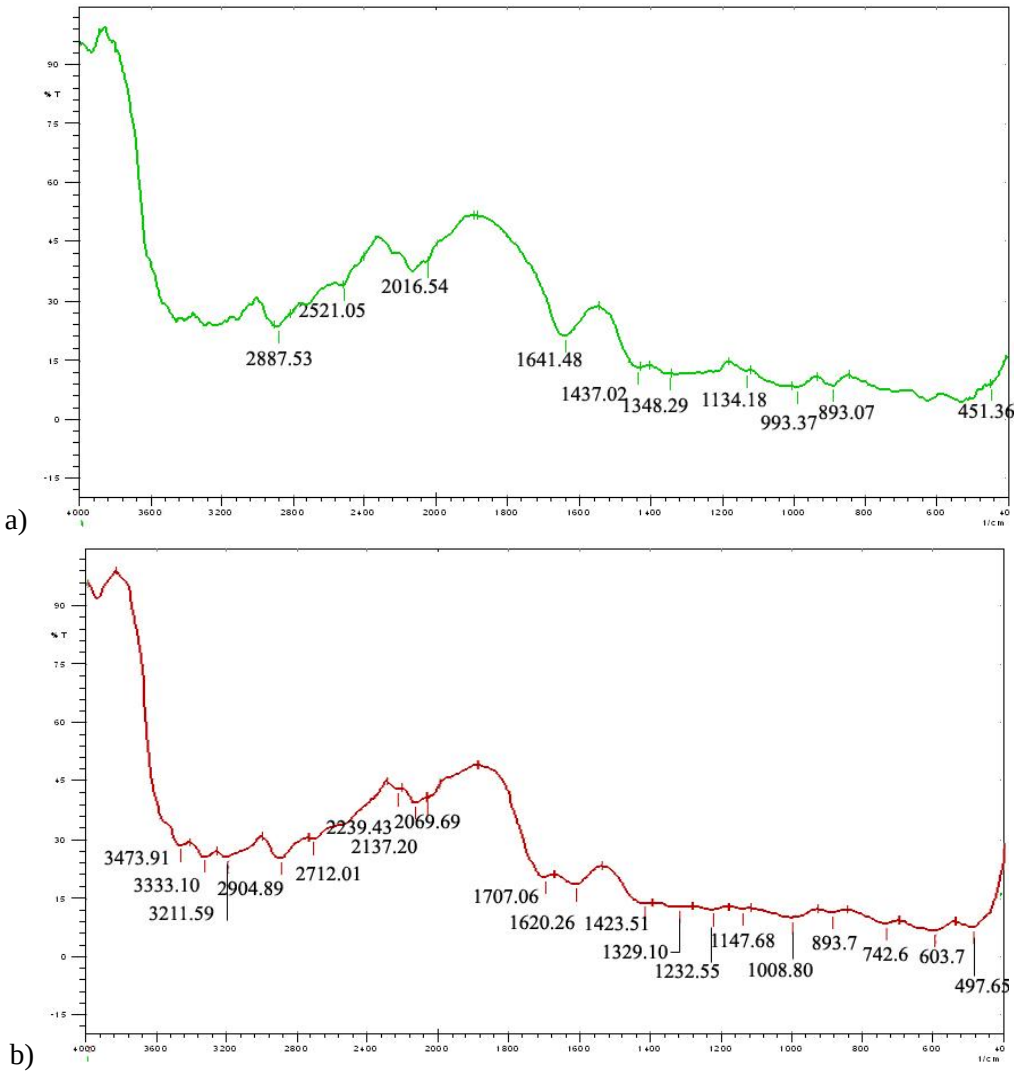

Figure 3. FTIR Spectrum for of a) cotton and b) herbal extract finished cotton fabric

The FTIR analysis of the herbal extract finished textile material shows that the peaks in the region 3300 -3500 cm^{-1} represents the –OH stretching of alcohols. Which represents the deposits of phenolic compounds in the finished textile than the untreated cotton. The peak near 2900-3300 cm^{-1} represents the stretching of –CH molecules. In the region of 1700 cm^{-1} formation of new peak represents the presence of –CO stretch, which in turns represents the oxygen groups of carboxilic acids [42].

Carboxylic acids have three bands caused by bonds in the COOH functional group. The band near 1700 cm^{-1} is due to the CO double bond. The broad band centered in the range 2700-3300 cm^{-1} is caused by the presence of the OH and a band near 1400 cm^{-1} comes from the CO single bond. This proves that the finishing treatment has imparted more amounts of carboxylic acids by the treatment [42].

This stretching in 1760 cm-1-1670 cm-1 confirms the presence of ester group. The Gallic acid could react with cellulosic -OH group which resulted in the ester formation in the treated fabric. The presence of [C (=O)-OH] carboxyl group and – (OH) group confirms the presence of carboxylic acids (ascorbic and gallic acid) and the presence of ester group proves the deposits of glycosides (saponin) in the fabric[43].

The FTIR analyses results supports the findings that, the finished textile material has more amount of active ingredients like tannin, phenolic compounds and carboxilic acids on the surface. The deposition of the active ingredients helps the fabric to act as an antibacterial material.

Antibacterial Study

In textile antimicrobial testing, two test methods—AATCC 100-2004 and AATCC 147-2004 are specifically use *Staphylococcus aureus* and *Klebsiella pneumonia* for the Gram-positive and Gram negative test organisms, respectively. Since they are human pathogen, the most of the research results focused on them, but these bacterial strains are not responsible for generating odor through the metabolism of human sweat[44]. *As micrococci, Bacilus* and *corynebacteria* do not pose a risk to human health (with the exception of *C. diphtheria*)[45], these bacterial species are rarely used for evaluating the antimicrobial efficacy of treated textiles. Species other than *corynebacteria* have also been found in the axilla to produce malodor in vitro[46].

Due to the high prevalence *corynebacteria* on human axillary skin, it is recommended to include these species in any evaluation of deodorancy treatments[47]. Hence in this study, the *Terminalia chebula* treated textile fabric were tested against the selected microorganism namely *corynebacterium* Sp, *corynebacterium* Sp, *B. licheniformis*., *Pseudomonas* Sp., *M. luteus.*, *Corynebecteriurn acnes, Staphylococcus aureus* and, *Escherichia coli* for their killing ability. The agar diffusion test result revealed that the selected herbal material has the potential antimicrobial activity against major odor causing organisms from 21 to 48 mm. The untreated fabric (control) shows bacterial growth under the test specimen. The zone of inhibition becomes apparent and its size provides some indication of the potency of the antimicrobial activity or the release rate of the active agent[48]. This results further evidences that, the finishing treatment reduced the bacterial population in next to skin fabrics which in turns reduces the axillary odor formation. The bacterial reduction in the treated textile is due to the presence of active ingredients in fabric after extract treatment.

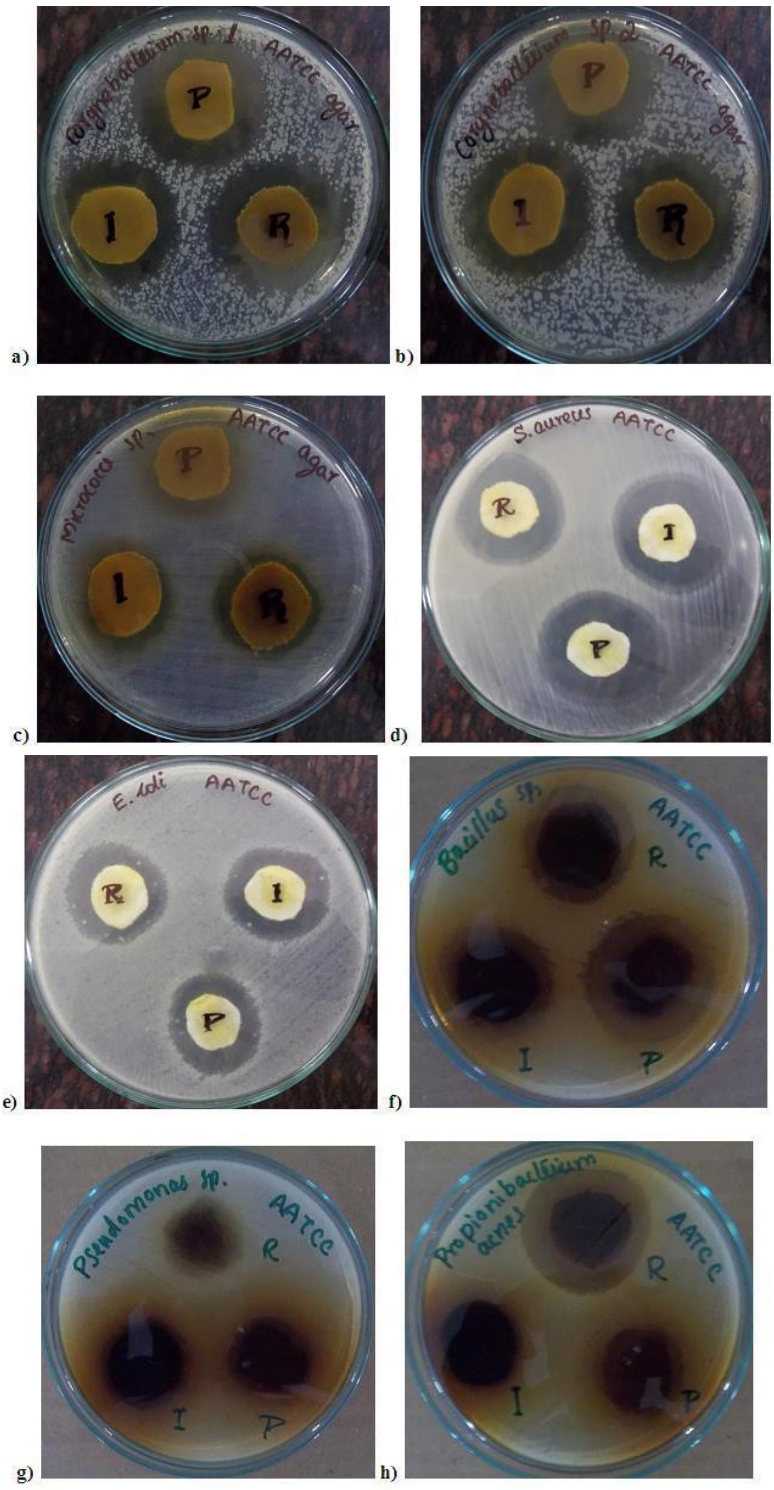

Figure 4. Zone of inhibition against the odor forming bacterial strains a) *corynebacterium* Sp; b) *corynebacterium* Sp; c) *M. luteus.,;* d) *Staphylococcus aureus;* e) *Escherichia coli;* f) *B. licheniformis.,*; g) *Pseudomonas* Sp; h) *Corynebecteriurn acnes.*

Table 2. Zone of inhibition (in mm) of treated textile material for different strains

S.No.	Bacterial strains	*Terminalia chebula* fruit Methanol extract			
		Control	Single Jersey	Rib (1X1)	Inter lock
1	*Staphylococcus aureus*	-*	43	44	48
2	*corynebacterium* Sp (*ATCC 3021*)	-	36	41	33
3	*corynebacterium* Sp (*MTCC 8730*)	-	34	31	37
4	*B. licheniformis*	-	40	38	34
5	*M. luteus*	-	26	28	22
6	*Corynebecteriurn acnes*	-	26	39	22
7	*Pseudomonas* Sp.,	-	22	C**	22
8	*Escherichia coli*	-	36	39	42

*Zone of Inhibition not found (No activity)
** Contamination

The chemical constitutions of *Terminalia chebula* extracts were well documented by Bhattacharya et al[49] and Anil Mahajan et al[39]. The detailed study of various active components in *Terminalia chebula* and their biological activity against various bacterial strains were listed elaborately by Anwesa Bag et al[50]. The phytochemical studies of *Terminalia chebula* by also confirmed the presence of phytochemical compounds like phenolic substance, Tannins, alkaloids and flavonoids. Presence of these compounds was proven both quantitatively and qualitatively. In our previous work[18], we characterized the methanol extracts of *Terminalia chebula* by HPLC and mentioned that, tannins and saponins are the major constituents. They are present in different molecular forms, like dimers, tetramers and polymers, depending from the mode of extraction. In aqueous or ethanolic extracts the lower molecules are prevalent. From a medicinal view most of them bring good results. They are effective against bacteria, viruses, parasites and cancer cells [51-53]. These studies confirm that the odor control is because of the (presence of phenolic compound) inhibition of bacterial growth and in turn controlling the metabolic by products of bacteria, which is the major source of odor by the active substance.

Effect of Anti-Microbial Treatment on Odor Intensity

The subjective study was performed after the antibacterial agent application. The results show same kind of trend with the fabric structure as mentioned earlier. But the intensity of odor was very less in the case of the fabric *Terminalia Chebula* treated. In the case of Rib structure 2 points are assigned for the odor intensity which is 47% less than untreated. There is a significant reduction observed in the case of all the fabric ($p<0.05$) with herbal treatment than the untreated, 46% and 35% reduction for single jerky and interlock respectively.

Bacterial isolation results

The results from bacterial isolation process immediately after wearing shows that, all the samples worn at axilla region consisted of less amount of bacterial population when compared to untreated. In this analysis, all the subjects, invariant of fabric structure consisted of *Staphylococcus sp., Bacillus sp.,* and *E.coli.*. Interestingly, the *Terminalia Chebula* extract treatment reduced the generation of major bacterial

strains responsible for odor formation like, *Staphylococcus aureus (MTCC 737), Corynebacterium Sp (MTCC 8730), Corynebacterium Sp (ATCC 3021), B. licheniformis (MTCC 429), M. luteus (ATCC 49732), Corynebecteriurn acnes (MTCC1951), Pseudomonas Sp.,(MTCC 6628), Escherichia coli (MTCC 1687).*

Bacterial Populations on Treated Fabrics

The Bacterial isolation procedure was carried out for the Herbal extract finished and worn samples. It is noted that the treated samples have very less amount of bacterial counts and species compared to the untreated worn samples. This result confirms that the reduction of bacterial population is due the antibacterial activity of the herbal material. Hence the reduction in bacterial count ultimately leads to the less amount of metabolic by product compared to the untreated one and hence produces very less odor. Rennie et al.[35] finding supports that; the population density of certain micro-organisms has strong association with the intensity of odor.

The bacterial populations on the treated fabric after the subjects worn were analyzed. The bacterial stains were isolated from the fabric by inoculating in the nutrient broth. After the 24 hour incubation, 1 ml of broth was plated in nutrient agar using spread plate method and incubated for 24 hours. The colony forming units per ml (CFU/ml) of broth were counted. The results are presented in Fig 4. It is observed that, there is a significant ($p<0.05$) reduction of bacterial count in the herbal extract treated and worn samples than the untreated ones. The reduction in the bacterial count is due to the potentiality of the antibacterial agent. Further from the results it can be understood that, the treated single jersey fabric produced more amount of micro-organism (188 CFU/ml) than the rib and interlock structure (116 and 124 CFU/ml respectively). This state is totally opposite in the case of untreated where the single jersey fabric produces less amount of micro-organism than other structures.

The results can be explained again in terms of the fabric thickness and mass per unit area. The increased fabric mass and thickness absorbs more amount of antibacterial agent. i.e., more amount of antibacterial agent per square unit. This is due to the high surface area in the case of Rib and Interlock structure. The higher the absorbed antibacterial agent in Rib and interlock, better the protection against the bacteria for long time. But in the case of single jersey, the less absorption resulted in the early growth bacteria. This was proved with simple weight calculation between treated and untreated textile material, the rib structure has 10.9% of weight add-on, which is higher than other structures as mentioned earlier.

We found a correlation between the number of bacteria presence in the fabric and the odor intensity by subjective analysis. The major reduction in number of bacterial strains per mL (CFU/mL) indicates that, this could be a reason for the odor intensity reduction in extract finished textile material. However, we found few *Staphylococcus sp.*, *Bacillus sp.*, and *E.coli* randomly even after finishing, in few subjects due to their multi resistant capabilities. The *Staphylococcus aureus is* one of the bacteria most found in the axilla region of human body[54]. The de contamination of this kind of multi resistant strains was not easy and they will decolonize immediately[55].

Table 3. Odor intensity and Bacterial Populations on Fabrics in CFU/ml

S.No	Fabric Type	Treated		Untreated	
		Odor Intensity	CFU /mL	Odor Intensity	CFU /mL
1	Single jersey	1.6	188	3	284
2	Rib	2	116	3.8	298
3	Interlock	2.6	124	4	292

CONCLUSIONS

The effect of textile structure on odor formation characteristics of herbal extract finished textiles has been discussed. The odor formation in textile depends with respect to the fabric structures, the thicker the structure and high mass/square meter causes more odor. This may be attributed to the fact that the restriction for the air and water vapor permeability through the fabric.

To reduce the odor formation in the textile material, *Terminalia chebula* extract was applied and the subjective studies were performed to analyze the odor intensity. From the results it is observed that, there is a significant reduction in odor intensity up to 47%. It is noted that the fabric with higher thickness (rib) possessed lower odor intensity than other fabrics after the finishing. These results were confirmed objectively in terms of bacterial isolation, FTIR analysis and anti-bacterial test. The isolation test reveals that, the finishing process significantly reduces the bacterial count (CFU/ml) in the treated textiles. The agar diffusion test results show strong inhibition against *Staphylococcus aureus (MTCC 737), Corynebacterium Sp (MTCC 8730), Corynebacterium Sp (ATCC 3021), B. licheniformis (MTCC 429), M. luteus (ATCC 49732), Corynebecteriurn acnes (MTCC1951), Pseudomonas Sp.,(MTCC 6628), Escherichia coli (MTCC 1687),* from 21 to 42 mm. FTIR analysis results confirmed that the presence of active ingredients on the surface of the fabric, which in turns makes the fabric more potential against the strains. The presence of phytochemical components like tannins, sapanin and flavonoids in the herbs[49,50] are the main reasons for odor reduction. The add-on percentage of the rib fabric was comparatively higher (10.9%) than other samples. This findings supports that the presence of more antibacterial agent is the reason for odor reduction. Thus, the research offers an alternative and eco-friendly way of finishing textile material which reduces the odor formation of textile material considerably, further it avoids odor generation in textile during day to day wear.

ACKNOWLEDGEMENT

The research work was funded by University Grants Commission of India under the Major Research Project scheme.

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