

Functional Clothing: A Novel Concept for Disease Therapeutics

¹Charu Gupta, ¹Dhan Prakash and ²Sneh Gupta

¹Amity Institute for Herbal Research and Studies,
Amity University UP, Sector-125, Noida-201303, India

²Department of Zoology, R.G.P.G. College, Chippi Tank, Meerut-250001, India

Abstract: Natural antimicrobial clothing or functional clothing is a unique and novel concept that is currently emerging for the treatment and prevention of various diseases like diabetes, hypertension, skin infections, high blood pressure, psoriasis, eczema, asthma, arthritis, rheumatism, cardiac problems and many others. Recent studies have shown that the fabric treated with the herbal extracts and essential oils develop the ability to inhibit the wide range of microorganisms. The herbal extracts are applied directly on to the fabric by methods like pad-dry-cure, micro-encapsulation or resin treatment, the fabric impart a bacteriostatic and/or bactericidal finish in textile. Since the raw material is obtained from natural resources, it is eco-friendly having economic, social and environmental benefits.

Key words: Antimicrobial • Ayurveda • Disease • Functional Clothing • Herbal • Textile

INTRODUCTION

Recent market survey has shown that the apparel consumers all over the world are demanding functionality in the product [1]. Some of the best examples of functionality are product attributes like wrinkle resistance, soil release, water repellency, flame retardancy, fade resistance and resistance to microbial invasion [1]. Among these, antimicrobial property of fabric is considered to be an important and inevitable parameter for garments which are in direct contact with the human body. Skin is the largest and most absorptive organ of the body and cotton textiles in contact with the human body offer an ideal environment for microbial growth. Microbial infestations pose danger to both living and non-living matters. Obnoxious smell from the inner garment (such as socks), spread of diseases, staining and degradation of textiles are some of the detrimental effects of bad microbes. The consumers are now increasingly aware of the hygienic life style and there is a necessity and expectation of a wide range of textile products finished with antimicrobial properties. The products currently available in the market with a range of antimicrobial properties under different trade names for textile industries are usually synthetic based and are not eco-friendly.

The concept of organic clothes came into existence for past 10 years only. There are numerous advantages of wearing organic clothes. Cotton t-shirt which is blended with polyester can release approximately one quarter of its weight in air as pollutants and ten times its weight as carbon dioxide. Each organic fiber t-shirt purchased eliminates the use of 150g of agricultural chemicals. It takes approximately one pound of chemicals to grow three pounds of conventional cotton, while organic cotton is grown chemical free. Lastly, the organic cotton is biodegradable. The present paper throws an insight about the Ayurveda clothing that has several biological properties for human health. The terminology 'Functional Clothing' similar to the well known 'Functional Food' has been introduced for the first time in the present paper.

History: The use of fabrics and garments to deliver health solutions is actually a very old concept that dates back to around 5,000 years old Indian system of Vedic healthcare called Ayurveda where 'Ayur' stands for health and 'vastra' stands for clothing. Ayurveda clothing is made from organic cotton fabric that has been permeated with special herbs and oils that promote health and cure special diseases depending upon the blends of embedded herbs and oils. Until about 100 years ago, people in many parts of India were using various forms of natural dyeing

in which they repeatedly dipped clothes in an herb-based preparation after each wash. The plants were also used for colouring the fabric because the dyes were natural and toxin free.

The history of cotton fabrics dates back to World War II, when they were used extensively for tentage, tarpaulins and truck covers, these fabrics are need to be protected from rotting caused by microbial attack. This was particularly a problem in the South Pacific campaigns, where much of the fighting took place under jungle like conditions. During the early 1940s, the US army Quartermaster Corps collected and compiled data on fungi, yeast and algae isolated from textiles in tropical and subtropical areas throughout the world. Cotton duck, webbing and other military fabrics were treated with mixtures of chlorinated waxes, copper and antimony salts that stiffened the fabrics and gave them a peculiar odour. At the time, potential polluting effects of the application of these materials and toxicity-related issue were not a major consideration. After World War II and as late as the mid-to-late 1950's fungicides used on cotton fabrics were compounds such as 8-hydroxyguanine salts, copper naphthenate, copper ammonium fluoride and chlorinated phenols. As the government and industrial firms became more aware of the environmental and workplace hazards these compounds caused, alternative products were sought.

A considerable amount of work was done by the Southern Regional Research Laboratory of the US Department of Agriculture, the Institute of Textile Technology (ITT) and some of the ITTs member mills to chemically modify cotton to improve its resistance to rotting and improve other properties by acetylation and cyano-ethylation of cotton. These treatments had limited industry acceptance because of relatively high cost and loss of fabric strength in processing. In addition, the growing use of man-made fibres such as nylon, acrylics and polyester, which have inherent resistance to microbial decomposition, came into wider use to replace cotton in many industrial fabrics [2].

In this age of innovation and technology-driven times, a new concept of developing wonder fabrics that contain tiny packets of goodness of herbs and essential oils has been developed. When these herbs and essential oils come in contact with body heat and wear, they slowly release their fragrance and medicinal benefits. Textiles with multifunctional finishes-coolant and antimicrobial finishes are employed in order to provide comfort to the wearers.

Ayurveda is a term used in Sanskrit that means life cloth and has been used to create different colours depending on the plants or herbs used for various health benefits. Herbal cloth is used by the Ayurveda health clinics in the treatment of broad range of diseases such as diabetes, skin infections, eczema, psoriasis, hypertension, high blood pressure, asthma, arthritis, rheumatism, cardiac problems and as general health products. The natural/herbal fabrics are 100% organic, completely free of synthetic chemicals, toxic irritants and are biodegradable. The colour of the fabric is derived from the medicinal preparation only that has specific health or wellness benefits proven by both traditional knowledge as well as clinical research [3].

Skin has the ability to absorb environmental toxins; similarly it has ability to absorb herbs found in our natural dyes. These herbs release their medicinal qualities into the body and strengthen the skin's ability to block and resist harmful substances [4].

Advantages of Herbal Clothing

Healing Properties: The herb-infused and herb-dyed organic fabrics act as healing agents and are absorbed through the skin. Each fabric is infused with specific herbs that can help to treat skin conditions such as eczema and psoriasis, the fabric also helps with conditions such as rheumatism, arthritis, blood pressure, diabetes and respiratory conditions, such as asthma. Certain fabrics also contain antibacterial or anti-inflammatory properties. The most effective time to wear herbal clothing is when the body is most at rest, such as during sleep, relaxation or meditation because this is time when the body is naturally healing and re-establishing balance. This is why herbal cloth is often used for sleepwear, bed sheets, towels, meditation clothes and cotton mats [5].

Improving Health: The micro-encapsulation technology that embeds tiny capsules into clothing fabrics, when these tiny micro-capsules come into the contact with body heat and wear, they slowly release their chemical payloads which can contain fragrances or skincare lotions or other chemicals which might have some topical beauty or medicinal value to the skin that comes into contact with the microencapsulated fabric. Herbal clothing helps to restore balance within the body systems and strengthens the immune system. This natural cloth is completely free from synthetic chemicals and toxic irritants and is totally organic, sustainable and biodegradable [5].

Process of Preparation of Herbal Clothing: The herbs are selected according to the traditional Indian medicine known as Ayurveda, with the infused cloth known as Ayurvastra. The organic cotton yarn or fabric is dyed in a carefully controlled mixture of herbal dyes depending upon the disease or ailment being treated. e.g. for diabetes, *Mimosa pudica*, cumin seeds, champa flower and shoe flower are combined in the herbal dye. The main herbs used in the herbal dye for arthritis are curry leaves. For skin diseases, the herbs used are turmeric, neem and sandalwood. Dyes for herbal clothes typically contains between 40 and 60 specifically blended and carefully prepared medicinal herbs, plants, flowers, roots, barks. The temperature of the dye, duration and number of dye soaked, the blend of herbs and even the equipment used are carefully controlled. Environment friendly processes are adopted for making herbal clothes in which the entire process is organic. The cloth is bleached with cow's urine which has high medicinal value. The gum that is used for dyeing is also herbal in origin. It does not pollute like synthetic dye and the waste is used as manure and to generate biogas. By coming in contact with herbal clothing, the body loses toxins and its metabolism is enhanced. For preparations of coir mats, the fibres are soaked in herbal dyes and then woven into coir mats. Herbal clothes are also being used for saris and in curtains [5].

Process of Dyeing Herbal Clothing: To create subtle and beautiful colours, the process begins by bleaching the natural cotton or yarn using a cow-urine-based preparation. The fabric is dried in direct sunlight and then a gumming substance containing plants like *Aloe vera* and camphor *Cinnamomum camphora* is applied. The fabric is then dipped in concoction called 'kashaya' that contains up to 40 medicinal plants, one of which is the primary herb selected for its specific wellness benefits. The gumming substances help the 'kashaya' take hold thereby giving the colours to the fabrics. The fabric is dried for 3 days and then kept for 15 days at room temperature for seasoning to allow the fabric to dry completely and the 'kashaya' to settle into the fabric. It is then washed and dried in the shade and kept for seasoning for another 15 days. It is a labour intensive process that involves handling large pieces of fabric that get heavy when wet dipping and wringing. It also requires focus to ensure standards like timing and consistency [5].

Utility of Antimicrobial Finishes: The present paper throws an insight about the Ayurveda clothing that has several biological properties for human health. The terminology 'Functional Clothing' similar to the well known 'Functional Food' has been introduced for the first time in the present paper.

Requirements for Antimicrobial Finish: Textile materials, in particular the garments are more susceptible to wear and tear. It is important to take into account the impact of stress strain, thermal and mechanical effects on the finished substrates. There are certain requirements need to be satisfied to obtain maximum benefits out of the finish. Firstly they should be durable to washing, dry-cleaning and hot pressing; should be selective towards undesirable micro organisms; should not produce harmful effects to the manufacturer, user and the environment; should comply with the statutory requirements of regulating agencies; should be compatible with the chemical processes; method of application should be easy; there should be no deterioration of fabric quality and should be resistant to body fluids, disinfections/sterilization [6].

Antimicrobial Finishing Methodologies: The antimicrobial agents can be applied to the textile substrates by exhaust, pad-dry-cure, coating, spray and foam techniques. The substances can also be applied by directly adding into the fibre spinning dope. It is claimed that the commercial agents can be applied online during the dyeing and finishing operations. Various methods for improving the durability of the finish are insolubilization of the active substances in/on the fibre; treating the fibre with resin, condensates or cross-linking agents; micro encapsulation of the antimicrobial agents with the fibre matrix; coating the fibre surface; chemical modification of the fibre by covalent bond formation; use of graft polymers and homo polymers and/or co-polymerization on to the fibre [7].

The antimicrobial textiles can be classified into two categories, namely, passive and active based on their activity against micro organisms. Passive materials do not contain any active substances but their surface structure (Lotus effect) produces negative effect on the living conditions of micro organisms (Anti-adhesive effect). Materials containing active antimicrobial substances act upon either in or on the cell [6].

There are many natural/ herbal products which show antimicrobial properties. Chitosan, a naturally occurring biopolymer has opened up a new avenue in this area of research [8]. The extracts from different parts of diverse species of plants like roots, flowers, leaves, seeds, etc. exhibit antibacterial properties [7, 9]. Many of the plants contain compounds like phenolics, terpenoids, flavonoids, alkaloids, polypeptide, poly-acetylenes, etc. which are antimicrobial. Some of these act as bactericides and some acts as bacteriostatic [10]. The use of herbal medicated products helps to reduce the opportunity for contamination by biological toxins and infectious pathogens and therefore reduce the spread of diseases to other patients [11].

Mechanism of Antimicrobial Activity: The antimicrobial substances function in different ways. In the conventional leaching type of finish, the species diffuse and poison the microbes to kill. This type of finish shows poor durability and may cause health problems. The non-leaching type or biostatic finish shows good durability and may not provoke any health problems [12].

A large number of textiles with antimicrobial finish function by diffusion type. The rate of diffusion has a direct effect on the effectiveness of the finish. For example, in the ion exchange process, the release of the active substances is at a slower rate compared to direct diffusion and hence, has a weaker effect. Similarly, in the case of antimicrobial modifications where the active substances are not released from the fibre surface and so are less effective. They are active only when they come in contact with micro organisms. These so-called new technologies have been developed by considering the medical, toxicological and ecological principles [11].

Effect of Antimicrobial Substances: Many antimicrobial agents used in the textile industry are known from the food stuff and cosmetics sector. These substances are incorporated with textile substrates comparatively at lower concentrations. It must be ensured that these substances are not only permanently effective but also that they are compatible with skin and the environment. A wide palette of antimicrobial compounds is now in use but differ in their mode of action. The following list demonstrates the polyvalent effect of the various antimicrobial substances.

- Materials with active finishes contain specific active antimicrobial substances, which act upon micro organisms either on the cell, during the metabolism or within the core substance (genome).
- Oxidizing agents such as aldehydes, halogens and proxy compounds attack the cell membrane, get into the cytoplasm and affect the enzymes of the micro organisms.
- Coagulants, primarily alcohols irreversibly denature the protein structures. Radical formers like halogens, isothiazones and peroxy compounds are highly reactive due to the presence of free electrons. These compounds virtually react with all organic structures in particular oxidizing thiols in amino acids. Even at the lowest level of concentrations, these substances pose particular risk to nucleic acids by triggering mutations and dimerization.
- One of the most durable types of antimicrobial products is based on diphenyl ether (bis-phenyl) derivative known as either 2, 4, 4'-trichloro-2' hydroxy diphenyl ether or 5-chloro-2-(2, 4-dichloro phenoxy) phenol. Triclosan products have been used for more than 25 years in hospitals and personal care products such as antimicrobial soap, toothpaste and deodorants. Triclosan inhibits growth of micro organisms by using an electro-chemical 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. The Triclosan when incorporated within a polymer migrates to the surface, where it is bound. Because, it 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.
- Quaternary ammonium compounds, biguanides, amines and glucoprotamine show poly cationic, porous and absorbent properties. Fibres finished with these substances bind micro organisms to their cell membrane and disrupt the lipo polysaccharide structure resulting in the breakdown of the cell.
- Complexing metallic compounds based on metals like cadmium, silver, copper and mercury cause inhibition of the active enzyme centers (inhibition of metabolism). Amongst these, the silver compounds are very popular and already been used in the preparation of antimicrobial drinking water.

- Chitosan is an effective natural antimicrobial agent derived from Chitin, a major component in crustacean shells. Coatings of Chitosan on conventional fibres appear to be the more realistic prospect since they do not provoke an immunological response. Fibres made from Chitosan are also available in the market place.

Natural herbal products can be used for antimicrobial finishes since there is a tremendous source of medicinal plants with antimicrobial composition to be the effective candidates in bringing out herbal textiles.

Herbal fabrics are light and make for perfect breezy clothes. The best part of cotton herbal cloth is that it is super-cool in summer and warm in winter. The fabric is quite similar to linen but it is more superior and comfortable than the latter. The fabric is hand-spun and woven. During the processing of fabric the cotton yarn is dipped in essential oils extracted from herbs like *Aloe vera*, *Saraca asoka* (Asoka), *Basil* (tulsi), *Adhatoda vasica*, *Cedar*, *Vitex negundo*, *Mimosa pudica*, *Piper nigrum* (black pepper), *Jasminum multipartitum* (wild jasmine) and *Azima tetracantha* (needle bush). Herbal clothing helps in fighting many common and prevalent diseases, helps the body to lose toxins and enhance the metabolism [13].

In a clinical trial study initiated by Ministry of Health with the state of Kerala Coir Department at Govt. Ayurveda College in Trivandrum on patients suffering from rheumatism, allergy, hypertension, diabetes, psoriasis and other skin ailments. For the study, all clothes, bed linen and mattresses for the resident subjects were dyed in herbs and the walls, floors and ceilings in the rooms were lined with Ayurveda coir mats. The results were remarkably good especially in cases of arthritis and skin ailments. When these fabrics come in contact with body's natural warmth, the oils in the clothes get activated and a nice fragrance emanates from them. The body then absorbs the oils and the healing process begins [13].

In another study, aloe gel was 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 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 [14].

In another study, an ecofriendly natural antibacterial finish has been prepared from the plant extracts for textile applications. Herbal extracts from *Ocimum sanctum* (tulsi leaf) and rind of *Punica granatum* (Pomegranate) have been applied to cotton fabric by method of direct application, micro-encapsulation, resin cross-linking and their combinations. All the treatments show good antibacterial properties for their fabrics and good washing durability upto 15 washes. The GC-MS studies reveal that the major components responsible for antibacterial properties are eugenol, germacrene and phytol [2].

In a study, the development of eye-pillow with coolant and antimicrobial effects of finishes is achieved by using a selected ecofriendly medicinal herb-*Glycyrrhiza glabra* (Licorice) roots. The extraction of herb was done by direct extraction method by using distilled water as the selected solvent among the other solvents like methanol, ethanol, chloroform, acetone and it is applied on the cotton fabric by pad-dry cure method in an optimized process condition. The results indicated that the treated fabric with 50% concentration of *Glycyrrhiza glabra* have high thermal resistance coolant and antimicrobial activity and it showed good resistance to washing upto 12-18 cycles [15].

Evaluation of Antimicrobial Activity: Various test procedures have been used to demonstrate the effectiveness of the antibacterial activity. Some of the tests used are agar diffusion test, challenge test, soil burial test, humidity chamber test and fouling test [11].

Agar diffusion test is a preliminary test to detect the diffusive antimicrobial finish. It is not suitable for non-diffusive finishes and textile materials other than fabrics. Objective evaluation of the antimicrobial activity is arrived at by making use of the challenge test where in which the difference between the actual bacterial count of the treated and untreated material is accounted for.

A series of test methods are available from AATCC (USA), DIN (International), JIS (Japan) and SN (Switzerland). The degree of antimicrobial activity of the active substance is expressed by the terms specific antimicrobial activity and general antimicrobial activity.

The general activity or the bactericidal effect in the Japanese standard is based on the difference between the initial bacteria count on the non-modified material (Ma value) and the bacteria count of the modified material after 18 h of incubation (Mc value). The specific antimicrobial activity or bacteriostatic effects is based on the difference between the bacteria count of the reference value (Mb value) and the sample after 18 h of incubation (Mc value). Due to the limitations of the existing system, a new test system ISO/TC/38/WG23 (test methods for antimicrobial finished textile products) has been evolved by considering the technological, dermatological and ecological aspects of the finish [11].

Herbal clothing can really cure diabetes, skin infections, eczema, psoriasis, hypertension, high blood pressure, asthma, arthritis, rheumatism and even some form of cancer. In a clinical trial, patients, suffering from rheumatism, allergy, hypertension, diabetes, psoriasis and other skin ailments, their clothes, bed linens and mattresses were dyed in herbs and the walls, floors and ceilings in the patient's room were lined with herbs coir mats so that the patients were surrounded by herbal medicated materials. Encouraging results were observed in the patients especially those suffering from skin infections. Many environment chemicals and toxins in conventional clothing are assimilated into the body through the skin. Ayurveda improve the skin's natural ability to block and resist harmful chemicals and toxins from entering into the body and improves wearer's health [5].

Herbal Clothing Protect Environment: The method used in the preparation of herbal clothing is completely based on Ayurveda. The herbal clothing are made of yarns of organic cotton fabric infused with organic herbs and medicinal plant extracts that promote health and cure special diseases depending on the blends of herbs and oils included in it. Herbal clothing is devoid of toxic chemicals and irritants and is absolutely organic and biodegradable [5].

The clothes are bleached in cow's urine which has many medicinal values. The colours are obtained from the herbs used and their parts like roots, flowers, leaves, seeds and barks and not from any artificial dyes. The clothes are then dipped in dyes at a controlled temperature and environment. The medicinal herbs used are turmeric, tulsi, neem, vetiver, sandalwood and indigo. All these herbs are blended with balancing herbs to make

delicate colours that remain everlastingly in the fibre. The dyeing can be applied to all natural fibres like cotton, silk, linen, wool, coir, hemp, nettle, bamboo to make eco-friendly textiles. Each herb caters a different medicinal property. e.g. a fabric with the properties of tulsi help fight against allergies and toxins; turmeric which has anti-inflammatory and antibacterial properties protect against skin infections [5].

Other Herbal Products: These include Bed sheets, night dresses for kids wear, dyed fabrics for any textile material made up of cotton and silk; yoga mats and prayer mats made up of wool and jute; carpets, rugs made of coir; dhoti, shawls etc made of handlooms. Each of the above products is packed in ecofriendly gift boxes [7].

Market Potential of Herbal Clothing: As it is well known fact that chemical dyes used in the textile industry have impact on human immune system. The chemical contents in textiles plays a major role in degradation of human skin, absorbs deep into the human system causing various health problems. Therefore herbal clothes provide an attractive alternative that not only prevents the disease but also perk up the immune system in the human body. This is a unique technology and thereby opening up a new area of entrepreneurship, job orientation and economic stability [1].

Working Principles of Herbal Clothing: The basic principle of herbal dyeing is that it is free from chemicals and protects human skin from many diseases by body transpiration. When skin comes in contact with herbal clothes, body losses toxins and its metabolism is enhanced. Absorption of herbal drug through skin is a passive process i.e. through barrier and the most effective time to wear herbal clothing is during sleep or meditation [8].

Diseases on Which Herbal Clothing Is Applicable: Cancer, skin diseases, respiratory diseases, skin discolouration, eczema, psoriasis, hypertension, asthma, rheumatism, arthritis, blood pressure, diabetes [12].

CONCLUSION

With advent of new technologies, the growing needs of the consumer in the wake of health and hygiene can be fulfilled without compromising the issues related to

safety, human health and environment. The scope of herbal clothing is endless and it is the effective way to keep the people healthy. The chief principle of herbal clothing is to maintain good health and adopt a healthy way of life. Herbal clothing is the medication for the future. It is the amalgamations of two oldest sciences known to mankind i.e. Ayurveda-the science of increasing longevity of a person and making of fabric textiles. This unlikely yet amazing combination also called natural clothing has the fabric yarns infused with plant extracts and herbs. The herbs are chosen depending upon the target disease. It is an attractive alternative to synthetic and synthetically dyed fabrics. Taping new potential antimicrobial substances, such as, chitosan from nature can considerably minimize the undesirable activities of the antimicrobial products.

Scientists all over the globe are working in this area and a few of them reported to have used antimicrobial finishes to make the fabric having antimicrobial as well as blood repellent properties. To carve a niche for textile materials, this kind of value adding finishes are the need of the hour.

REFERENCES

1. Rangari, N.T., T.M. Kalyankar, A.A. Mahajan, P.R. Lendhe and P.K. Puranik, 2012. Ayurveda: Herbal couture technology in Textile. *Int. J. Res. Ayur. Pharm.*, 3(5): 733-736.
2. Sathianarayan, M.P., N.V. Bhat, S.S. Kokate and V.E. Walunj, 2010. Antibacterial finish for cotton fabric from herbal products. *Ind. J. Fib. Text. Res.*, 35: 50-68.
3. Geissler, S., 2006. Extraction of natural dyes for textile dyeing from coloured plant wastes released from the food and beverage industry. *J. Sc. Food Agric.*, 86: 233-242.
4. Manonmani, G., T. Ramachandran, R. Rajendran and E.M. Rajesh, 2009. Chromogenic and antimicrobial activity of natural dye finished knitted fabrics. *Man-made Text.*, pp: 94-96.
5. Rangari, N.T., T.M. Kalyankar, A.A. Mahajan, P.R. Lendhe and P.K. Puranik, 2012. Ayurveda: Herbal Couture technology in Textile. *Int. J. Res. Ayur. Pharm.*, 3: 733-736.
6. Mucha, H., D. Hoter and M. Swerev, 2002. Antimicrobial Finishes and Modifications. *Melliand Intl.*, 8: 148-151.
7. Joshi, M., S. Wazed Ali and R. Purwar, 2009. Ecofriendly antimicrobial finishing of textiles using bioactive agents based on natural products. *Ind. J. Fibr. Text. Res.*, 34: 295-304.
8. Elayarajah, B., R. Rajendran, C. Balakumar, B. Venkatrajah, A. Sudhakar and P.K. Janiga, 2011. Antibacterial synergistic activity of Ofloxacin and Ornidazole treated biomedical fabrics against nosocomial pathogens. *Asian Text. J.*, 1: 87-97.
9. Naik, P., D. Ushamini and R.K. Somashekar, 2007. Impact of municipal solid waste dumping on ground water quality-a case study in Bangalore district. *Ecol. Env. Conserv.*, 13: 759-760.
10. Cowan, M.M., 1999. Plant products as antimicrobial agents. *Clin. Microbiol. Rev.*, 12: 564-582.
11. Massey, D., P. Geol and M. Swerev, 2008. Antimicrobial Finishes and Modification. *Melliand Intl.*, pp: 151.
12. Huang, W. and K.K. Leonas, 2000. Evaluating a one-bath process for imparting antimicrobial activity and repellency to non woven surgical gown fabrics. *Text. Res. J.*, 70: 774-782.
13. Sethi, N., 2012. Clothes go herbal. *Ind. Perf. Quart. J. Pub. Essent. Oil Assoc. Ind.*, 56: 15-16.
14. Jothi, D., 2009. Experimental study on antimicrobial activity of cotton fabric treated with aloe gel extract from Aloe vera plant for controlling the Staphylococcus aureus (bacterium). *Afr. J. Microbiol. Res.*, 3: 228-232.
15. Veni, K. and A. Mani, 2012. Preparation and characterization of medicinal herb Glycyrrhiza glabra and a study of antimicrobial and thermal properties on cotton fabrics for eye syndrome. *J. Text. App. Technol. Manag.*, 7: 1-7.