V. SUMMARY AND CONCLUSION

The summary and conclusion pertaining to the study entitled “Fabrication and Enhancement of Plasma Treated Cotton, Tencel Cotton and Modal Cotton with Anti-bacterial and Mosquito Repellent Finish” are summarized.

Phase – I: Survey

The survey was conducted to elicit information from 50 shops that are care products and 100 adolescent students who use armpit pads and mosquito repellent textile for bed linen. From the survey the following information were gathered such as type of materials, durability, cost and other finishing agents in and around Coimbatore district and adequate information was also collected from market about the existing products and their demands.

From the above collected information cotton, tencel and modal yarns were selected. The regenerated cellulosic yarn can generate new features and high tech performance in the fabric. The inherent characteristics and blending concepts allow synergistic effects to meet the requirements of modern functional textiles. Hence the cotton, tencel and modal yarn (40s count) were selected for this study. The selected yarn was converted into 40s count plain weave with the combination of 50:50 tencel cotton, 50 : 50 modal cotton and 100% cotton fabric woven into 20 metres each fabric and 2 metres from each was kept aside which was used as control sample for this study.

Pre-treatment

Cellulosic fabric need some form of treatment to make them suitable for dyeing and finishing. This treatment which removes natural or added impurities is called preparatory treatments such as scouring and bleaching. This was done on all fabrics except the control samples.
Application of Value Added Finish

The textile industry is searching for innovative production techniques to improve the product quality. Plasma is one such technique to improve the study. Plasma surface treatments show distinct advantages, because they are able to modify the surface properties of inert materials, sometimes with environment friendly devices. Plasma technologies provide an environmentally-friendly and versatile way of treating textile materials in order to enhance the variety of properties such as wettability and durability.

The potential application of performance finishes in textiles is as wide as the imagination of textile manufacturers. For giving high value addition, research and development activities are required in this area to improve strength and aesthetic properties without affecting normal textile properties. The above finishes are used for the value addition of textile with improved performance properties. Oxygen plasma treatment was given to the produced fabrics before finishing as it improves the capillarity in cellulosic fabrics.

Phase – II : Pilot Study – Selection of Herbs

For selection of herbs suitable for fabric, a pilot study was carried out with few herbs namely neem, pomegranate and rhizome of turmeric, prickly chaff flower, marigold, orange peel, guava leaf, keelanalli and vetiver.

Two plants for anti-bacterial finish namely prickly chaff flower, guava leaves, two plants for mosquito repellent finish namely keelanalli and vetiver were selected for this study.

Herbal Extraction Procedure

The extraction of selected natural sources was carried out by various methods like aqueous, alkaline, acidic and alcoholic methods. As alcoholic extraction using ethanol was more effective to extract the active ingredients of the natural sources, it was used in the present study.
Phytochemical Analysis

A portion of the dry extract was subjected to the phytochemical screening using the method adopted. Phytochemical screening revealed the presence of alkaloids, phenols, flavonoids, terpenoids and tannins.

Selection of Optimization Parameters

A series of experiments were carried out for anti-bacterial and mosquito repellent finishing. The trial parameters namely pH, concentration, temperature and time were optimized to determine the parameters.

Selection of Finishing Techniques

The pad-dry-cure method gives best result and the finishing agent impregnated thoroughly during pilot study. Hence pad-dry-cure method was selected for this study.

Phase – III: Fabric Evaluation

The unfinished, finished and plasma treated finished fabric were evaluated by the standard testing procedures to measure the physical, mechanical, comfort properties and water absorbency of the fabric samples. The surface morphological features of herbal finished and plasma treated herbal finished fabric were evaluated by using scanning electron microscope.

Herbal Analysis

Phytochemical analysis of the selected herbs indicated the presence of different compounds. These were confirmed by the various colour reactions exhibited by the plant extracts when subjected with different acids and alkalis.
Anti-bacterial and Mosquito Repellent Compound Identification Methods

FTIR Test

The FTIR technique was used to find out the compounds present in the selected herbs. The peaks in the spectra are an indicator of the amount of components present.

Evaluation of Anti-bacterial Finishes

In the present study, the anti-bacterial effect of the fabrics was determined by Agar diffusion test and Parallel streak method. Anti-bacterial activity was confirmed by zone of inhibition and colony population.

Mosquito Repellency Test

The finished and plasma treated herbal finished fabrics were evaluated for mosquito repellency. The results were studied with standard evaluation method.

Product Development

From the plasma treated finished fabrics, two products were developed such as arm pad and cushion cover. These products were used for performance study.

Wash Durability

The arm pad and cushion cover were subjected to washing upto 25 washes. Then the washed products were evaluated for their anti-bacterial and mosquito repellent property at the intervals of 5, 10, 15 and 20 washes.

Findings of the Study

The following are the salient findings of unfinished, finished anti-bacterial and mosquito repellent and plasma treated finished fabrics when
compared with their respective control sample and within the group and between A, B and C groups.

**Fabric Weight**

The fabric weight of the anti-bacterial finished fabric samples in all groups, sample AG₂ had increased 4.32% and AP₁ had decreased by 0.04% when compared with their respective control samples A, B and C. Increase in fabric weight was significant at 1% level.

**Fabric Thickness**

Fabric thickness of the sample CP₂ has increased by 2.9% and AG₂ and AP₂ have decreased by 0.25%. This may be due to the adherence of the finishing material on the fabric structures. Statistical analysis also shows a significant difference at one per cent level.

**Fabric Count in Warp and Weft Direction**

Fabric count increased maximum value in both warp and weft samples CP₁ 20.21 per cent and AG₁ 1.19 per cent in all three groups of samples ABC. Statistical analysis also proved that there was a significant difference at one per cent level in all the samples except group C in weft directions. This may be due to the shrinkage and expansion during finishing treatment.

**Fabric Tensile Strength in Warp and Weft Direction**

With regard to the tensile strength, the sample AP₂ increased by 16.17 per cent and the sample CG₂ has reduced in its strength by 41.29 per cent. The comparison was made with its control groups A, B and C in both warp and weft direction. Statistical analysis also proved the level of significance at one per cent.
Fabric Elongation in Warp and Weft Directions

The fabric elongation has decreased maximum in sample BP₂ in weft direction (41.95 per cent) and increased by 128.08 per cent in sample BG₂ in weft direction when compared between the groups of samples in warp and weft direction.

Abrasion Resistance

Abrasion resistance value has increased maximum in sample BP₂ (32.11 per cent) and in sample CP₂, -90.90 per cent has decreased when comparison was made with respective their control groups of A, B and C. The statistical analysis proved that there was a significant difference at one per cent level.

Fabric Stiffness in Warp and Weft Direction

Among the stiffness of unfinished, finished and plasma treated samples, the CP₁ -33.68 has decreased by 33.68 in its values and sample BG₂, 32.86 per cent had increased when compared within the group and between the group of warp and weft direction. This is because of the reaction of the finishes. Statistical interpretation reveals one per cent of significant difference of all the groups of fabric.

Air Permeability of Fabrics

The fabric air permeability has increased in sample BP₂ by 6.81 per cent, the sample AP₁ have low by 45.80 per cent. Statistical analysis also express that there is a significant difference at one per cent level.

Fabric Drop Test

The absorbency property of the finished and plasma treated finished fabrics were increased in water absorbency. The sample BP₂, CG₂ increased by 61.08 per cent and sample AG₁ 6.77 per cent has low absorbency when compared within the group and between the groups A, B and C. Statistically
also it was confirmed that there exists one per cent level of significant difference among the samples.

**Fabric Sinking Test**

With regard to fabric sinking test the finished samples have taken less time to shrink by the sample CP₂ 85.62 per cent and more time taken was by the sample CG₁ (15.62 per cent). Statistical analysis proved one per cent level of significance.

**Vertical Wicking Test**

As far as the vertical wicking test is concerned the result was found to be improved in finished fabric to great extent. The sample BP₂ exhibited 65.11 per cent and AG₂ has decreased by 41.75 per cent when compare within the group and between the groups A, B and C. The statistical data proved that it was significant at one per cent level among all the groups.

**Salient Findings of the Mosquito Repellent Finished Fabrics**

**Fabric Thickness**

The thickness of the sample B₁ has increased by 14.2 per cent and C₂ has decreased by 7.69 per cent when compared within and between the groups A, B and C. The statistical data proved that it was significant at one per cent level among the group of A, B and C.

**Fabric Tensile Strength in Warp and Weft Direction**

In warp direction strength increased in sample C₂ by 46.03 per cent and the sample B₁ has decreased by 6.35 per cent over control groups of A, B and C both warp and weft. Statistically one per cent level of significance was found.
Fabric Elongation in Warp and Weft Direction

The fabric elongation within and between groups A, B and C in both warp and weft sample, C₁ has increased by 68.62 per cent and in sample B₂ 56.25 per cent has decreased. This was proved statistically at one per cent level.

Fabric Abrasion Resistance

Among all the three groups of samples, the sample C₁ and C₂ 38.46 per cent exhibited highest by 38.46 per cent and A₂ had decreased by 5.88 per cent in abrasion resistance property when compared with their control group A, B and C. The statistical analysis also proved that there was a significant difference at one per cent level between the groups.

Fabric Stiffness in Warp and Weft Directions

As for as the stiffness is concerned in warp and weft directions, the sample C₁ has decreased by 12.5 per cent in weft direction and the sample B₂ had increased by 33.5 per cent when comparisons made with their control samples and between the groups A, B and C in both warp and weft direction. This was proved statistically at one per cent level.

Fabric Air Permeability

The fabric air permeability is higher in sample C₂ by 19.11 per cent and lower in the sample A₁ by 8 per cent when comparison made within and between the groups A, B and C. This may be due to the porosity that had been created in the fabric samples, because of the finishing and plasma treatment made the fabric more porosity. The air permeability properties have one per cent level of significance in group A and C. B group has five per cent level of significance.
Drop Test

The fabric absorbency has increased in the finished fabrics. As for as the sample B₂ (66.88 per cent) and the sample A₁ (11.27 per cent) are concerned absorbency value have reduced when compared within and between group of A, B and C. The statistically data proved that it was significant at one per cent level among all the samples.

Sinking Test

As far as sinking test is concerned, the sample A₁ increased by 53.98 per cent, in sample C₂ decreased by 32.51 per cent when comparison made within and between groups A, B and C. The sinking properties exhibit one per cent level of significance between all the samples.

Vertical Wicking Test

The rate of absorbency increased in all the finished and plasma treated finished samples. The absorbency of sample B₂ has increased by 96.80 per cent and decreased by 15.14 per cent in C₁ when compared within and between group A, B and C. Statistically also it was confirmed that there exists one per cent level of significant difference among the groups.

FT-IR Analysis – Functional Groups Finding

The presence of the functional groups such as O-H, C-H is responsible for the anti-bacterial and mosquito repellency activity.

Phytochemical Findings

Phytochemical screening test shows the presence of alkaloids, flavanoids, tannins, phenols, terpenoids and saponins. This plant powder seems to have the anti-bacterial and mosquito repellant property chemical components.
**Scanning Electron Microscopic Analysis**

Morphology of the fabrics was analyzed using high resolution SEM suitable accelerating voltage and magnification. From the photograph, it is clear that continuous polymer film has formed on the finished fabric. This improves the durability of the anti-bacterial and mosquito repellent effect.

**Agar Well Diffusion**

Anti-bacterial activity imparted by the plant powders were assessed by the agar well diffusion method. This was confirmed by the zone of inhibition observed in each plant treatment.

**Bacterial Reduction – AATCC 100**

The anti-bacterial reduction tests were evaluated by the bacterial reduction count of colonies present in finished and plasma treatment finished fabrics. The combination of 50 : 50 tencel : cotton fabric exhibit the maximum bacterial reduction percentage.

**Wash Durability**

The anti-bacterial activity was assessed using *S. aureus* and *E. coli* after 15 washes. The bacterial reduction caused by herbal treatments were observed and recorded. The treatments exhibited to have a positive impact on reduction of bacterial population.

**Mosquito Repellency Evaluation**

The mosquito repellency results of the plasma treated finished tencel cotton fabric showed higher repellency percentage of 76 when compared with and without plasma treated fabrics.
Wear Study Findings

The plasma treated herbal finished and herbal finished fabric were constructed into arm pad and cushion covers. The selected adolescents girls were asked to wear the arm pad. After wear, the arm pads were subjected to 5, 10 and 15 washes. The plasma treated herbal finished arm pads could control bad odour even after 15 washes. The cushion covers were subjected to wash after 5, 10 and 15 uses. The respondents opine that the plasma treated herbal finished cushion covers could resist mosquito bite even after 15 washes. The respondents were satisfied with the plasma treated herbal finished products.

General summary of the study

The herbal extract application had been done successfully by exhaust and pad dry cure method on cotton, tencel cotton and modal cotton with and without plasma treated fabrics. The anti-bacterial activity of herbal finished (Pisidium guajava and Achyranthes aspera) fabric was studied qualitatively and quantitatively. Effectiveness of plasma treated herbal finished was also assessed after washing cycles. From the study following conclusions were derived.

The application of herbs such as *Pisidium guajava* and *Achyranthes aspera* on cotton, tencel cotton and modal cotton fabrics showed good anti-bacterial activity than without plasma treated fabrics. The fabrics pretreated with oxygen plasma only could further enhance the anti-bacterial property of the fabrics. The plasma gas containing reactive oxygen species which could enter the cell and eventually cause the death of the bacterial cell. The hydrophillic nature of carbonyl groups present in the oxygen plasma pre-treated fabrics also increased the anti-bacterial activity.

The present study focused on the mosquito repellency efficiency of the *Phyllanthus niruri* and *Vetiveria zizanioides* herbs. The ethanolic extracts were
finished on the cotton, tencel cotton and modal cotton fabrics and the mosquito repellency rate was tested by improved Excito chamber method.

The natural material and herbal extract treated with plasma is being capable of repelling mosquito on the fabric to a greater extent. The herbal products are eco-friendly and quite stable for prolonged period, and the above findings would be helpful for the scientific community in finding the right durable and reusable textiles for various medical applications.

The outcome of the survey showed that the awareness on the advantages of using natural herbs treated textile products to enhance life style and women’s health was lacking. Therefore, the research focused on developing procedures to impart certain functionalities such as anti-bacterial and mosquito repellent characteristics to selected fibres used in the study.

It would be onerous task to consider many different type of fabrics and natural finishes. Hence the work focused on cotton and regenerated textile fibres such as tencel and modal. Likewise, four different natural products were chosen which have shown to posses anti-microbial and vector repellency characteristics. Two different sets of products were developed with one set having no pretreatment before herbal finishing and the other set having plasma pretreatment. As plasma is a surface modification technique such a treatment would enhance the reactivity of textile to subsequent chemical treatments such as natural herbs finishing treatment employed in the study. Altogether 21 different fabrics as shown in the Chapter III (Table IV) were developed for further evaluation.

Results indicated not only the type of herbal finishes influenced respective functionality, but also the nature of the fabric substrates influenced the overall property of the fabrics. For example, tencel/cotton blends treated with prickly chaff flower herbs gave the highest bacterial efficacy in the case of both *E. coli* and *S. aureus*. These results have been provided in Section IV.
In the case of mosquito repellency, plasma pretreated fabric after been treated with 50% vetiver and 50% keelanelli finish gave the highest repellency compared with untreated fabric.

Based on these points, It is finally concluded that the natural herbs such as; guava leaves (*Psidium guajava*), prickly chaff flower (*Achyranthes aspera*), keelanelli (*Phyllanthus niruri*) and vetiver roots (*Vetiveria zizanioides*) can be used as viable functional finishes for imparting anti-bacterial and mosquito repellency to different textile substrates like cotton, tencel cotton and modal cotton plain woven fabrics. Results from the study show that the plasma pretreatment has a positive effect on the final characteristics of fabrics. It is our understanding that plasma pretreatment will not add much cost to the overall process. Additionally, plasma treatment enhances further chemical treatments as reported similarly by many researchers for different applications that provide added advantages such as improved functionality to fabrics. Results from the research showed that natural products can serve as effective alternative materials to synthetic organic compounds, and therefore could be highly useful for the society as well as to the environment as a whole. With the necessity to reduce carbon footprint and environmental burden it is important for the textile industry to develop green processes and products for improving health and protect the environment.

The work reported in the thesis focused on natural herbs as a viable alternative to synthetics and pave the path forward for the industry to make inroads into sustainable manufacturing.

**Limitation of the Study and Future Direction**

This thesis based on voluminous experimental work has shown that the interaction between the type of substrates, pretreatment techniques and chemical finishes influence the overall results. Due to limitation of time, the thesis could not delve in depth on the chemical nature of fibres and its effect on the final characteristics of the fabrics. A major research programme that
would come out of the study could focus on the interaction between the chemistry of different fibres. It will be interesting and useful to gain understanding on such interactions and its effect on the functional characteristics of fabrics. While this study has shown that plasma as a pretreatment could have positive influence on functional properties such as vector repellency, as plasma is a surface treatment. Its durability over a period of time is an important aspect points that has to be seriously investigated.

As this research study predominantly focused on natural herbs, the availability and that cost aspects have to be discussed and taken into consideration towards technology translation.
REFERENCES

BOOKS


JOURNALS

• Charles W. Anderson, Clayton K. Nielsen, Cyrus M. Hester, Ryan D. Hubbard, Janice K. Stroud and Eric M. Schauber, “Comparison of Indirect and Direct


• Naresh, M., Saraf, Dr. Ashok G. Sabale and Dr. Vaishali Rane, G., (2007), “Antibacterial Agents in Textile Industry”.


APPENDIX – I
GENERAL INFORMATION OF COTTON, TENCEL
AND MODAL YARN

History of Cotton

Cotton, the most widely used fibre in the world has a long fascinating history. Scientists searching caves in Mexico found bits of cotton balls and pieces of cotton cloth that proved to be at least 7,000 years old. In the Indus River Valley in Pakistan, cotton has been grown, spun and woven into cloth 3,000 years B.C. At about the same time, natives of Egypt’s Nile Valley were making and wearing cotton clothing. Arab merchants brought cotton cloth to Europe about 800 A.D. (Thomas, 2006).

According to Ajay and Rakesh (2007) there is evidence that cotton was cultivated in India, Pakistan, Mexico and Peru 5000 years ago. In these two widely separated parts of the world, cotton must have grown widely. Then people learned to cultivate cotton plants in their fields. Cotton has been cultivated for more than 5000 years and archeological finds indicate that cotton was grown and used for textile purpose in the Indus Valley well before 2100 B.C. The oldest known “cotton yarn” was produced in Mohenjo-Daro in Pakistan 3000 years ago (Kaplan, 2002). The advent of man-made fibre is a serious challenge to the supremacy of cotton, which had held undisputed away over the textile world from time immemorial (Kulkarni, 1999).

Cotton cloth was used by the people of ancient China, Egypt, India, Mexico and Peru. In America, naturally colored cotton was used extensively. Cotton was grown in the southern U.S. Colonies as soon as they were established. Throughout the 1600s and 1700s, cotton fibre was separated from cotton seeds by hand.

Cotton was first spun by machines in England in 1730. The industrial revolution in England and the invention of the cotton gin in the U.S. paved the way for the important place cotton holds in the world today. Although cotton is
the most common textile fibre now in use, it was the last natural fibre to attain commercial importance. Cotton textiles were found in the West Indies and in South America by explorers in the 15th and 16th centuries.

Cotton Yarn

Cotton the “white gold” is the most precious gift of nature to the mankind contributed by the genus “Gossypium” (Mishra, 2000). The cotton is known as “king of fibre” has prime position as the principal clothing fibre, which is not able to meet the growing demand due to deforestation and increase of population (Ranganathan, 2005). Cotton is the most commercially significant fibre in the world, easy to cultivate in large quantities and utilized in a wide variety of textile products. It is a hygroscopic material, hence it easily adapts to the atmospheric air conditions (Rakesh, 2005). Cotton is produced in over 50 countries worldwide, averaging 20 to 24 million metric tons per year. Cotton accounts for more than 75 per cent of the total fibre consumption in the spinning mills and 56 per cent of the total fibre consumption in the textile (Malik, 2007).

Cotton plays a vital role in the Indian economy. Cotton enjoys an extremely positive image due to its naturalistic and gentleness to the human skin (Shriveleela, 2004). The cotton industry provides a large number of jobs and livelihood opportunities in rural and urban India. It ranks second largest cotton textile manufacturing countries in the world (Swaminathan, 2005). Cotton fibre grows from the surface of seeds in the pods and balls of a bushy mallow plant. It is composed basically of a substance called cellulose. Variation among cotton fiber also occurs because of growth conditions, including such factors as soil, climate, fertilizer and pests (Naresh, 2005).

Cotton is the strong and reasonably low in price and its possess so many interesting properties like good absorbency and strength. It can be washed with strong soaps and detergents and have a good affinity for dyes and prints (Shukla, 2005).
Properties of Cotton

The major property of cotton plays an important role in fibre length, length uniformity, strength, elongation, fineness and maturity (Basu and Gotipamul, 2003). Cotton has the excellent properties like absorbency, biodegradable, breathable, drape, easily sterilized, high wet-strength, insulating properties, non-allergic, renewable resource, softness and water retaining capacity. The property of cotton to withstand severe treatment, especially during dyeing and finishing (Barker and Midgley, 2007).

Cotton is not affected by friction and is a good conductor of heat. It is highly resistant to sunlight, heat and alkalies but it is deteriorated by the action of acids and oxidizing agents such as hydrogen peroxide and chlorine bleaching compounds (Hall, 2004). The length is the most important property which decides the grade or quality of the raw cotton (Nakamura, 2000). Cotton cloth is cool and has a soft handle. It creases easily but it is also easy to iron. It is durable and has a good drape. It is absorbent and is slow to dry (Furter et al., 2007).

Cotton fibres are made up of cellulose. The fibre length varies with type and quality within the ranges from 11 μ to 20μ. Cotton is a relatively strong fibre with strength 22.37 N/Tex and breaking elongation at 7 – 9 per cent (Nair et al., 2009). Mostly the fibre has 8.5 per cent of moisture but it has ability to absorb, 15 – 20 per cent of the moisture (Gienandt, 2006). It is very absorbent owing to this countless polar –OH groups in its polymers these attract water molecules which are also polar (Stephens, 2002).

The length is the most important property which decides the grade or quality of the raw cotton (Nakamura, 2000). The cloth is cool and has a soft handle. It creases easily but it is also easy to iron. It is durable and has a good drape. Many microorganisms attack cotton cause mildew. The mildew discolors rots and weakens the fibre most fungi reproduced by means spores largely present in the air and are attacked cotton (Mishra, 2000).
Cotton is defined as a white fibrous substance covering seeds harvested from the cotton plant. Each cotton fibre is a very interesting mass of cellulose formed by the interplay of natural forces. The cellulose of which cotton is made is a very tough and durable substance. The cotton fibre is associated with a number of other substances, notably waxes, pectic products and mineral substances. So it is always a first step in the art of dyeing and finishing, purifying the cotton as completely as possible (Hall, 2004).

Cotton is a staple fibre whose length varies from ½ inch to 2.5 inches. Cotton with short length is known as short staple and with a long staple. Long staple is used for manufacturing fine quality cloth; short staple is used for rough quality cloth manufacturer (Sushma et al., 2005).

Cotton can be easily dyed with basic dyes and natural dyes. It has a swelling capacity regarding aqueous solution. It is resistant to moth and also non-allergic to body (Gienandt, 2006). It absorbs perspiration quickly. It has good color retention and also durable. It is biodegradable and breathable (Asha, 2007).

It is easy to dye and print. The classes of dye which may be used to color cotton are Azoic, direct, reactive, sulfur and vat dyes and all bleaches can be safely used on white cotton (Mullick, 2006). Cotton is a wonderfully versatile and globally important fibre that is used for a vast variety of fibre and food products (Menezes, 2004). It is popular because it is comfortable year around (Sivaramakrishnan, 2007). It is the most widely used textile fibre, because of its inherent properties it has been able to hold an important position in spite of the advent of the regenerated synthetic man-made fibre (Bhattacharya, 2004).

Uses of Cotton

Cotton is used to make a number of textile products which include terrycloth, used to make highly absorbent bath towels and robes, denim, used to make blue jeans, chambray, popularly used in the manufacture of blue work shirts and corduroy, seersucker and cotton twill socks. Underwear and
T-shirts are made from cotton. Bed sheets often are made from cotton. Cotton is used to make yarn used in crochet and knitting (Rastogi, 2009). Cotton has good strength, electricity, heat conductivity and high resistance to degradation by heat and its characterized by excellent properties like grape, biodegradability, water retaining capacity and non-allergenic properties (Ragavan, 2002).

It is used in industrial application: as tire cords, bags, shoes, medical supplies and equipment (Gotipamul and Basu, 2003). It has many versatile intrinsic qualities that make it a fibre for all masses and occasions (Narayanan, 2006). Cotton upholstery fabrics are attractive and durable, comfortable, easy to spot clean and retain their appearance well (Kadolph and Langford, 2002).

Cotton the king of fibre retaining its importance in the apparel industry in spite of developments in synthetic fibres (Alat and Sarath, 2005). Cotton fibre due to its comfort characteristics, finds wide array of application ranging from apparels to technical textiles such as industrial wipes.

The home textiles such as bed linens, table linens, draperies, upholstery, slip cover fabrics and towels are frequently made from cotton. Industrial products containing cotton are as diverse as wall covering, book binds and zipper tapes. Unspun and raw cloth finds its uses in mattresses, upholstery for stuffing purposes (Kumar and Uma, 2002).

The cotton fabrics have been so well known and so extensively used throughout the world for hundreds of years that the spinning of the cotton fibre into yarn, the wearing of cotton fabric and many of the finishing processes used for cotton goods come first to mind and naturally serve as foremost examples in a study of fibre and fabric. Cotton has been of service to mankind for so long that is versatility is almost unlimited and new uses are constantly being discovered. It can be depended on to serve many purposes.

It is exclusively used in apparel fabrics for men and women wears and household fabrics like bed sheets, towels, rugs and carpets. Cotton is blended
with other man-made fibres like polyester, viscose, acrylic etc. to be used for a variety of purposes. It can also be used in industrial applications as tire cords, bags, shoes and medical supplies and equipments (Rakesh, 2005). Cotton (cotton wool), compress, gauze bandages, tampons or sanitary towels, cotton swap, gloves and caps (Kothari, 2000).

**Tencel Yarn**

Tencel is the cellulosic fibre developed by Courtaulds one of the pioneer companies in rayon production. Tencel is the first commercialized local fibre by Courtaulds UK, which is produced from the natural cellulose in wood pulp.

Tencel (Lyocell) is the first new fibre before 30 years, and being made of wood pulp of cellulose, it is the first new natural fibre in a last longer than cotton. It is manufactured fibre, but it is not synthetic. It begins with cellulose which is processed with a non-toxic, recyclable dissolve agent, most of which is recycled back into the fibre manufacturing process. It can be woven in 100 % Tencel fabrics, or blended with other fibres. Tencel is yarn dyed and absorbs colors much better than most other fibres, and it is particularly striking in deep ones, taking on a jewel like appearance.

Tencel is one such lyocell fibre and like viscose it is made from wood pulp (Sarah, 2008). It is a biodegradable fabric and is becoming increasingly popular as an eco-friendly alternative to fabrics such as polyester, nylon and cotton (Cole, 2002). It is often described as a man-made silk equivalent and is a tough fabric which is blended with other fabrics, eg., cotton (Rastogi, 2009). Tencel fibres have made a special impact on the worldwide textile market since their appearance.

**History of Tencel**

The first fabrics made with wood pulp were made as far back as the mid 19th century. They were not universally accepted or very profitable. At the end of the 19th century, a method for creating rayon out of wood cellulose
became popular, and rayon became one of the first man-made fibres, as a silk substitute, and an inspiration to later produce locally.

Tencel was introduced into our country in 1978. It is called “Green Fibre in the 21st century” which was an international green environment certificate. Tencel is the new cellulosic fibre developed by Courtaulds, one of the pioneer companies in rayon production. It is produced from natural cellulosic in wood pulp of eucalyptus (Burrow, 2008 and Collar and Tortora, 2001).

The Tencel research program began in the mid 70s. The pure research with the aim to produce staple fibres and filament yarn was taken up under the title “new cell” in 1976 by the American Enca Corp at the time, and Enka Research in Obernburg / Germany. In 1987 Akzo granted a license to Lenzing (Austria) and to Courtaulds (UK) in 1990. Lenzing (Austria) gave the name Lenzing Lyocell. It took 16 years and an investment of US$ 500 million to develop this fibre and its unique manufacturing process in which virtually all the solvent used was recycled.

Properties of Tencel

Tencel staple grades for carding give enhanced fabric strength, especially in the wet state, high fabric bulk and low linting characteristics. Tencel short cut fibres are produced in cut lengths of 4 – 29 mm depending on the application. Tencel short cut fibres have been specifically optimized for downstream process such as air laid, wet laid and paper making. Tencel is the advanced non woven cellulosic fibre, providing a peerless combination of performance purity and softness (Asian Technical Textiles, 2009).

Tencel materials are so comfortable to wear and give a special touch feel. Tencel is the first cellulosic fibre to draw its strength from nanotechnology. As the result of the controlled and regular structure of nano fibrils, different properties can be introduced into Tencel fabric. These are hydrophilic and guarantee excellent moisture absorption combined with optimum moisture management. Tencel has a cooling effect when
temperature is hot and a warming effect when it’s cold. Tencel is said to regulate body temperature, especially when used as sport wear.

The fibres exhibit special properties like excellent wear, comfort properties, the temperature control effects, the reduced bacterial growth (Schuster et al., 2004). Tencel acts as important comfortness by offering protection against mites and bacteria (The Indian Textile Journal, 2009). Tencel offers unique moisture transport. It controls and regularly absorbs moisture. Tencel absorbs 50 % moisture than cotton.

The fibres may be purely because of the difference in physical structure and properties and their effect on the chemical behavior. Since tencel fibres are man-made, they are more uniform and the yarn and fabric surface are smoother and softer than cotton. Therefore, rubbing fastness and resistance pilling, are more in the case of tencel.

A new range of tencel garments for people with skin disorders are found in the modern medical textiles. Surveys have shown that as many as 20 per cent people believe they have sensitive skin. They would also benefit from choosing tencel clothing. Tencel will also improve patient comfort in other medical applications. The optimum moisture management creates an unattractive climate for bacteria. Bacteria which spread the most disagreeable smells have only a slight chance of multiplying on tencel.

Tencel reduces the growth of these microorganisms both automatically and in an absolutely natural way. The growth of bacteria with tencel is two thousand times lower than compared to synthetics. It is an excellent alternative for the replacement of fossil raw material. Furthermore Tencel is the most attractive and reliable solution among biopolymers (Asian Technical Textiles, 2009).

Natural intelligence properties the fibre guarantees an optimum night’s sleep, skin friendliness and an in building a feeling of freshness, ensure a dry and sound sleep even in summer. Moreover the protection against mites and bacteria are important comforters.
Uses of Tencel

Tencel, the new age cellulose fibre has successfully continued to gain market shares in a range of applications example in sports, active and casual wear. Tencel has recently been very successful in the home textiles sector. It is also used in blends with high quality cotton fibres in the clothing sector. Tencel produce apparel fabrics of both knit and woven shirts with good versatility. It satisfies a wide range of fabric needs from fine fashion ladies, light weight blouse and dress wear though moderately heavy skirting and suiting.

The fiber is highly successful in technical applications, for example, in separations for the batteries in hybrid power cars. Tencel is the ideal choice for demanding areas such as hygiene, medicine, household, cosmetics, automotive and technical application (Asian Technical Textiles, 2009). Viscose and tencel a reliable partner for demanding applications in the medical industry, providing the absorbent component for the extremely sensitive areas such as advanced operating theatre, drapes, swabs gauzes to aid surgeons in their work. It is also widely used for the production of non-woven wet wipes. Tencel process produces less effluent, useless dyestuff and is more cost effective. Primary applications are cut and sew knits for tops, active wear and intimate apparel as well as knitwear and woven for shirting, sport wear and home furnishing textile.

Modal Yarn

Modal is extracted from beech wood which is also known as the “mother of the forest” and is a veritable soil enhancer. Beech trees which grows in northern and central Europe is an important habitat and home to a variety of animals (Wilson, 2005). Modal is a processed bio-based textile made from reconstituted cellulose. Yarns can be made from wood pulp of various trees and modal uses beech wood. This new wonder fabric combines the benefits of nature fair and the fantastically the soft feel of modern micro
forms with the hygroscopicity of cotton and luster of silk (Sparavigna and Wolf, 2005).

**History of Modal**

Modal was first developed by the Austria Lenzing Company, who trade marked the fabric's name. Modal may be used on its own or blend with cotton, spandex or other textiles. Modal fibres were initially developed in the 1930’s for industrial uses in tires, conveyor belt and hose pipes (Thilagavathi, 2005). Lenzing started promoting modal in India only in the late 1990s, when economic liberalization became effective and import duties were brought down. The consumption rate in India is 4000 tonnes. Modal is used all over the world by numerous brand manufactures and is employed to make textiles extremely soft and pleasant (Singh, 2004).

Modal is a kind of cellulose recovered fibre, which is produced by Austria Lenzing Company. It adopts the European Schneider Zelkova as the raw material, made into wood pulp and then it is spun and made into the fibre. It is a 10 per cent natural fibre, harmless to the human body, and can decompose naturally, green environmental protection (Abu,2011). The fibre is manufactured according to a special viscose spinning process from high quality wood pulp.

**Properties of Modal**

Fibres made of modal display a silky gloss, which produces a shine similar to mercerization when blended with cotton, a pleasant soft touch and drape and excellent wear properties.

Modal is a 100 %biodegradable fabric. This fabric is bio-based, rather than other natural fibres (Selcen, 2013). Modal is combined with modern microforms. It is commonly blended with cotton as the cross fibre is similar (James and Micheal, 2003). It is about 50 per cent more hygroscopic, or water-absorbent, per unit volume than cotton. It is designed to dye just like cotton and is color fast when washed in warm water.
Modal fibre is replacing the cotton from its current dominant market. It is eco-friendly, 100% biodegradable characteristics have made it accepted globally within a short period of time. Modal fibres are defined in International Standard ISO 206: 999 (E) as high wet modulus, high breaking strength, regenerated cellulose fibres produced by using viscose rayon and regeneration bath compositions which allow greater molecular orientation during stretches and coagulation of the fibres.

Modal is a manufactured cellulose fibre obtained by processing high breaking strength and high wet modulus. Modal is soft, smooth and delicate fibre with excellent moisture absorption and release capacities. The structure of modal is stapled with well arranged fibrillar structure which does not become rough even after repeated use. Modal yarn is the best replacement for textiles made from polynosics as it satisfies the comfort requirements, with good breathing properties besides, being skin friendly and ease to care (Pane, 2001).

Modal is a regenerated cellulose fibre, which when wet, remains stronger and distorts less than either a cubrammonium or viscose. These fibres have a round cross section with smooth surface and a silky luster. Micro modal is a typical HWM fibre with all the advantage such as high wet modulus, high dry and wet strengths, average fibre elongation, high degree of polymerization of cellulosic, good resistance to swelling, water retention values, shrinkage and chemical and temperature resistance. Modal fibre is sometimes called artificial cotton (Seyam, 2003).

Modal is currently called the new wonder fibre. This fibre combines the benefits of natural fibre and the fantastically soft feel of modern microforms. It has more hygroscopic or water absorbent, per unit volume than cotton. Modal fibres are dimensionally stable and do not shrink or get pulled out of shape when wet. Modal fabric has softness, good drape and is comfortable for wearing. It is a good material and has good moisture regain and air permeability (Mahapatra, 2007).
The effect of the finished modal garment maintains anti-crease properties and has relatively easy care. It remains soft and lustrous after several washes. A textile made from modal do not fibrillate, pill and are resistant to shrinkage and fading.

**Uses of Modal**

Modal is the perfect fibre for fabric worn day and night, sports and active wear in home textiles. It is used for a variety of terry cloth products. Modal is also used for shirts, blouses, dresses, ladies, men’s and children's clothing. Technical application of modal is tire cord, abrasive ground fabric, rubber cloth and other coating supports.

Among the areas of application which have found favor are knitwear and woven, inner and outer garments. In home textiles, it is used for a variety of terry-cloth products. In the US, pure modal has been used in household linens such as towels, bathrobes and bed sheets. It is also the main textiles used in manufacturing of panties, sleepwear, casual and clothing lines. The fibres have found a wide variety of uses in clothing, outerwear and household furnishing.

Lenzing modal is used for soft flowing tops and lingerie; exclusively in knit wear markets having high-end apparel / non apparel products. And also used for socks and stockings as well as in technical applications, such as fire cord, abrasive ground fabric, rubber cloths and other coating supports.
APPENDIX – II
GENERAL INFORMATION OF FINISHING

Finishing

The textile finishing covers an extremely wide range of activities, which are performed on textiles before they reach the final customer. Today customers demand more value for money through different levels of comfort, durability, functionality, health and safe protection (Sundar and Kumar, 2005). All finishing processes are designed to increase the attractiveness or serviceability of the textile product. Finishing is the process that incorporates some specific function on textiles by using chemical or physical methods. It is done to fibre, yarn or fabric either before or after fabrication to change the appearance or the performance. All finishing add to the cost of the end product and the time it takes to produce the item (Stephens, 2002). The finishing is done on a fabric after weaving or knitting. Finishes also helps to introduce variety and improve its serviceability and durability. Finishes basically are processes applied to fabrics to improve its properties and its end use. Finishing may be done in the mill where the fabric is manufactured or sent to special centers called “converters” or “finishing houses”.

When the fabric comes out of the loom they do not appear attractive. While they are under process of spinning they get dirty. In order to clean them, improve their appearance, bring out their distinctive characteristics and prepare them for the market, they are made to undergo some additional processes after they have left the loom (Parvathi, 2007). The fabric contains impurities which are natural to the fibre or it is oiled and many have oil stains. So it becomes necessary to give the preliminary treatments such as desizing, scouring, and bleaching. Basic finishes are those that increase the beauty and attractiveness of the cloth and cover the defects. They add weight, body or warmth (Meenakshi, 2009). Basic finishes are also called preparatory finishes.
Preparatory finishes are finishes that are added at the beginning of the textile production process.

The aim is to prepare fabric for subsequent processing operations such as dyeing, printing and finishing which is called wet processing. The whole operation of textile wet processing may be called as value addition process, which converts the grey textile material into aesthetically pleasing and comfortable wear fabric (Shukla, 2005).

Finishing treatments depend on various factors such as the nature of the fibre, texture of the fabric, its physical properties and end-use of the material and so on. Some preliminary treatments are essential for finishing. These are applied before the final finishes and given to yarn or fabric that come from the spinning, weaving or knitting. It contains impurities which are natural to the fibre or it is oiled and may have dirt and stains. So it becomes necessary to give these treatments. These are bleaching, scouring, desizing and singeing (Gupta, 2007). This finishing process varies according to the fabric variety.

**Classification of Finishing**

Finishes are classified in several ways. It is classified as mechanical and chemical finishes on the basis of techniques used (Naresh, 2005). Permanent, durable, semi durable and temporary finish on the basis of degree of performance. Generally it is classified as basic finishes and special or functional finishes (Mullik, 2006). The types of finishes that can be applied to the textile product that can alter or modify the stability and durability of the textile (Mel, 2010).

The mechanical finishing are the cost effective means of value addition to finished fabric with limited investments, a wide range of products can be produced without generating effluent. The mechanical processes are carried out in tumble driers, calendars, compactors, raising, sewing and bushing machine.
Chemical processes involve those processes that use the application of chemicals to the fabric. Finishes obtained by deposition of chemicals such as starch, china clay, oils fats and waxes, synthetic resins, rubber latex, cellulose acetate, cellulose ethers, optical bleaching agents and so on. Physical or mechanical finishes causing some physical changes in the fabric. Some mechanical devices such as rollers, brushes, needles, plates, perforated cylinders, etc. are used during finishing. Chemical finishes involve a chemical reaction or treatment of the fabric by alkalies, acids, bleaches and resins (Murphy, 2000).

Basic finishes are applied almost all fabrics to improve their appearance. Special finishes are applied, when needed to prepare the fabric for special purpose or end use (Gokum, 2007). A permanent finish generally involves a chemical process that changes the fibre structure. So that it will not alter subsequently. A durable finish may last throughout the life of the fabric. A semi durable finish will last through several launderings or dry cleaning. A temporary finish will be removed or substantially reduced when the fabric is washed. The aesthetic finishes affect the appearance of the fabric only, example dyeing, printing but the functional finish also improves the performance by catering to a specific and use of crease resistant, water repellent and antimicrobial finish (Parvathi, 2007).

**Scouring**

According to Nakamura (2004) the process of removing the impurities and color pigments, etc. contained in the fibres since its origin, the gluey material adhered during the spinning and weaving process, the trash and the oil etc. is called as scouring. The fabrics are immersed in appropriate time in hot water or hot liquid, having the usual soap and soda dissolved in it and then they are washed.
The purpose of the process is to remove any sizing, dirt, oil or other substances that may have adhered to the fibres in the processing of the yarns or in the manufacture of the cloth (Smith, 2006).

**Bleaching**

Hydrogen peroxide is the most frequently employed textile bleaching agent (Singh and Tiwari, 2005). Bleaching is done to whiten the cloth which comes from the loom and is grayish brown in color (Neelima, 2009). Cotton, linen, silk and wool is bleached to make them pure white. Bleaching consists of a chemical reaction between a reagent (usually an oxidizing or reducing agent) that destroys the molecular bonds responsible for the pigmentation that is the source of the colored or off-white, state of the fibres. It can be carried out at various points in the manufacturing process, from fibres to fabrics (Kaplan, 2008).

The method using bleaching powder, hydrogen peroxide, sodium peroxide, potassium permanganate utilizes the oxidation effect of these. Whereas, the method using sulfurous acid, soda or hydro-sulfite etc. utilizes the effect of reduction (Meenakshi, 2009). These are chosen very carefully depending upon the fibre content as the same bleach is not suitable for all fabrics. Further, bleaches tend to damage the fabric, so it is done under controlled conditions of temperature and concentration. Finally, thorough rinsing is essential to remove all traces of bleach (Garg et al., 2005).
APPENDIX – III

GENERAL INFORMATION OF NATURAL SOURCE

Natural Source

Details of the natural herbs used in the study such as Guava (*Pisidium guajava*), Prickly chaff flower (*Achyranthes aspera*), Keelanelli (*Phyllanthus niruri*) and Vetiver (*Vetiveria zizanioides*) are provided in Appendix–III.

India has always been renowned for the wide variety and excellence of her textiles during the Vedic period itself. People used to wear clothes which are purely organic, made out of cotton which itself had the medicinal property. They use different herbs with medicinal property for coloring, dyeing and processing of the cloth (Hussain, 2011). Medicinal plants are still used on a regular basis. There is a renewed interest, especially in developed countries in using plants to treat humans, livestock and pets.

Plants have been used for healing purpose and in the treatment of various diseases from time immemorial. They are the source of some very potent drugs which play a vital role in human ailments to the extent that survival of the human race depends on plants. India is considered to be a rich emporium of drug plants mainly used in preventive and curative medicine. The World Health Organization estimates that about 80 per cent of people living in developing countries rely almost exclusively on traditional medicines for their primary health care needs (Trivedi, 2007).

Dinesh Kumar (2005) says that there are many herbal products which show antimicrobial properties. Extracts from different parts of diverse species of plants like root, flower, leaves, seeds etc. exhibit antimicrobial properties. Different plants contain compounds like phenolic, terpenoids, quinines, tannins, flavonoids, alkaloids, polypeptide, polyacylenes, alkaloids, locations etc. which are acting as an antimicrobial. An innovative approach to make the cloth microbe resistant is to apply the plant extracts containing active
substances. This natural antimicrobial substance is not only eco-friendly but also from renewable sources (Thilagavathi and Kannian, 2008).

Natural antimicrobial agents are non toxic and non-allergic and do not cause the problems of microbial resistance. When the clothes are processed with the medicinal herbs instead of the synthetic dyes and chemicals, the cloth imparts antibacterial, anti-inflammatory, antioxidant properties (Hussain, 2011). India has about 45,000 plant species among them, several thousand have been claimed to possess medicinal properties. Over the past decade, substantial progress has been made in research on the natural products for the treatment of several diseases.

The World Health Organization estimates that about 80 per cent of people living in developing countries rely almost exclusively on traditional medicines for their primary health care needs. The medicinal plants are the backbone of the traditional medicine. This means that 3300 million people in the underdeveloped countries utilize medicinal plants on a regular basis (Pravin, 2007).

The following are the reasons for using natural source.

- Many people believe that plants are less toxic and safe than manufactured drugs.
- Many people believe that plants are more natural than manufactured drugs.
- Medicinal plants often are more accessible than manufactured drugs (Manisha and Visha, 2004).

An innovative approach to make the cloth microbe resistant is to apply the plant extracts containing active substances. This natural antimicrobial substance is not only eco-friendly but also from renewable sources (Thilagavathi and Kannaian, 2008). Natural antimicrobial agents are non toxic and non allergic and do not cause the problems of microbial resistance. When the clothes are processed with the medicinal herbs instead of the synthetic
dyes and chemicals, the cloth imparts antibacterial, anti-inflammatory, antioxidant properties.

**Guava Leaves (Psidium guajava)**

- **Kingdom**: Plantae – Plants
- **Order**: Myrtles
- **Family**: Myrtaceae – Myrtle family
- **Genus**: *Psidium* L. – Guava P.

Guava is a tropical fruit, cultivated mainly in the Asian countries. It is quite similar in shape to a pear and has a rind that is green in color and changes to yellow when it becomes over-ripe. Inside the rind which is consumed along with the fruit and not peeled, there is flesh that is either white or pinkish / reddish in color. Guava is quite rich in Vitamin C. Guava has been associated with healing of wounds, when applied externally.

Guava has general haemostatic properties and can be used for treating bleeding nose, gums and minor internal hemorrhaging. Guava helps cure dysentery by inhibiting microbial growth and removing extra mucus from the intestines. Guava helps the body in combating free radicals produced during metabolism and aids in preventing age related chronic diseases such as Alzheimer’s, cataract and rheumatoid arthritis. Guava is one of the richest sources of dietary fibre and thus is good for those suffering from constipation (Khoja et al., 2003).

The health benefits of guava include treatment of diarrhea, dysentery, cough, cold, skin care, blood pressure, weight loss and scurvy etc. The leaves of the guava tree are medicinal in nature. It is widely used as antispasmodic, antidiarrheal, antidepressant, anti-inflammatory, antiquing and sedative effects (Baby, 2010). They yield an essential oil that has a pleasant odor and used in perfumery and confectionery industries. The powdered form of the bark and leaves has been found to be beneficial in treating wounds and sores. Guava leaves are used for tea. Guava leaves, roots and fruits have been used for the prevention and treatment of diarrhea and diabetes as a folk
medicine and reported having an anti-mutagenic effect (Arima, 2002). Guava leaves have a high content of antioxidants. Antioxidants can help prevent and repair cell damage, thus slowing the ageing process. Guava leaves have an anti-allergic effect and can inhibit the release of histamine.

Guava strengthens and tones up the digestive system and even disinfects the same. Guava, having high content of roughage, no cholesterol and less digestible carbohydrates is good for those trying to lose weight. Guavas can improve the texture of skin and help avoid skin problems. Juice of raw and immature guavas or decoction of guava leaves is known to bring relief in cold (Sharma, 2006).

*Psidium guajava* acclaimed as “poor man’s apple of the tropics”. The guava is a perennial plant native to Mexico, Northern South America and Central America. There are about 100 species belonging in the myrtle family. They have green foliage, white flowers and fruit that are produced at the start of summer. At maturity, the guava tree can reach up to 25 feet high. Guava is an evergreen growing wild in the Torrid Zone and subtropics. The health benefits of guava include treatment of diarrhea, dysentery, cough, cold, skin care, blood pressure, weight loss and scurvy etc. The leaves of the guava tree are medicinal in nature. They yield an essential oil that has a pleasant odour and used in perfumery and confectionery industries. The powdered form of the bark and leaves has been found to be beneficial in treating wounds and sores.

Guava leaves have a high content of antioxidants. Antioxidants can help prevent and repair cell damage, thus slowing the ageing process. Guava leaves have an antiallergic effect and can inhibit the release of histamine. The decoction of guava leaves can be gargled to relieve both tooth ache and boils on the gums. This is chiefly due to the abundance of astringents in its fruits and in leaves. Controlling cholesterol and blood pressure, treating acne and hangovers, increasing sperm production and protecting the prostate are also said to be health benefits of guava leaves.
Prickly Chaff Flower (*Achyranthes aspera*)

- **Kingdom**: Plantae
- **Family**: Amaranthaceae
- **Genus**: Achyranthes
- **Species**: Aspera

It is about 0.3 m to 0.9 m high, stems erect, pubescent, swollen at the nodes, leaves opposite, short petiole, margins undulate; flowers numerous, utricle oblong, cylindrical, enclosed in the hardened perianth, brown seeds oblong ovoid (Ahmad, 2010).

*Achyranthes aspera* has been used as a medicine since ancient times for treating a large number of diseases. Different parts of the plant used for the different ways (Narayan, 2006).

These leaves are used as antiseptic, anthelmintic etc. (Chopra et al., 2007). Antibacterial activity of prickly chaff flower leaves against both the gram positive and gram negative bacteria. Antibacterial activity of alcoholic and aqueous extracts of leaf of *Achyranthes aspera* against *E. Coli* and *S. aureus* (Zafar, 2000).

*Achyranthes aspera* is a species of plant in the Amaranthaceae family. It is distributed throughout the tropical world. It can be found in many places growing as an introduced species and a common weed. It is an invasive species in some areas, including many Pacific Islands environments. This plant is popularly supposed to act as a safeguard against scorpions and snakes by paralyzing them. It is described as pure, pungent and digestive, a remedy for phlegm and inflammation of the internal organs, piles, itch, abdominal enlargements and rheumatism and for enlarged cervical glands. The Hindus in preparing caustic alkaline preparations use the ashes (Vikusiae et al., 2001).

The diuretic properties of the plant are well known to the natives of India. Different parts of the plant are ingredients in many native prescriptions.
in combination with more active remedies. *Achyranthes aspera* contains triterpenoid saponins which possess oleanolic acid as the Anglican. Ecdysterone an insect molting hormone and long chain alcohols are also found in *Achyranthes aspera*. In Western India the juice is applied to relieve toothache. The ashes with honey are given to relieve cough and rubbed into a paste with water it is used as an Anjan (eye salve) in opacities of the cornea. The stem of the plant is used as a toothbrush; an infusion of the twig is also used as a wash for tooth pain. Roots are useful in the treatment of cancer. Decoction of roots is used in stomach troubles.

The decoction prepared from the samoolam of this plant is given for inflammatory condition of the body. It is also a potent diuretic. The decoction of the roots is helpful to cure abdominal disorders. The dried powder of the leaves in the dose of 2 to 5 grams is given with honey for diarrhea. The dried powder of the roots along with an equal amount of Trikadugu is given for cough. Leaf juice is a helpful remedy given for skin diseases like Pruritis, Scabies etc. The paste of leave is applied externally for toxic baits. Nayuruvi Chambal or ash is a good remedy for bleeding piles and abdominal problems.

Prickly chaff flower is an erect prostrate, annual or perennial herb, often with a woody base. Found throughout tropical Asia, Africa, Australia and America. It is abundant in dry places and waste lands from the sea shore to 200 m high. This plant has been mentioned in manuscripts of Ayurveda and Chinese medicines. It is described in “nighantas” as purgative pungent a remedy for inflammation. Hindus used ashes for preparing caustic alkaline preparation. Betaine and achyranthine are the principle alkaloids identified from the whole plant. Seeds contain achyranconthes and saponin. The presence of ecosystem is also reported. Shoots contain essential tannins glycosides (Chopra et al., 2007). The entire plant is medicinally useful. The whole plant is much valued for its pungent, diuretic and emmanagugue properties (Daniel, 2006). It has pungent, astringent, diuretic, alterative, antiperiodic and purgative properties. Plants are used on piles, skin eruption, ophthalmic, dysentery, eye and liver complaints, rheumatism, scabies and
leprosy. Leaves are useful in gonorrhea. Roots used in cancer, stomach troubles and blood stains. Seeds are useful in renal dropsy, leprosy, bronchial affections. It is also effective in skin disorders. It is also used to treat heart disorders and blood pressure.

**Keelanelli (Phyllanthus niruri L.)**

- **Kingdom**: Plantae
- **Family**: Euphorbiaceae – Spurge family
- **Genus**: Phyllanthus – Leaf flower
- **Species**: Niruri

The word “Phyllanthus” derived from green words billion means leaf and Anthos means flower which and can be understood as bearing of flowers on the leaves (Purohit and Vyas, 2005). An erect, branched, glabrous, shallow rooted, 20 – 95 cm high, annual herb (Vardhana, 2008). Some annual herb leaves are small, pale yellow color flowers are greenish yellow. It is a weed commonly found in different parts of India.

**Vetiver roots (Vetiveria zizanioides (L.) Nash)**

- **Kingdom**: Plantae
- **Family**: Poaceae – Grass family
- **Genus**: Vetiveria
- **Species**: Zizanioides

Vetiver grass (Vetiveria zizanioides) has been proclaimed by green field to be the right, indeed the only plant for long-term control of soil erosion and for promoting in situ moisture conservation. The grass is adapted to be a wide range of climatic and edaphic conditions. The Vetiver grass has low maintenance and minimal space requirements. Vetiveria zizanioides is generally non palatable to grazing animals and thus can be established and maintained in free grazing areas without resorting to tanking or requiring a change in grazing habits.
APPENDIX – IV
INTERVIEW SCHEDULE TO ELICIT INFORMATION
FROM THE MARKET

1. Name
2. Address
3. Type of material used for arm pad : Natural □ Synthetic □
   If natural, kind of fibre used :
   Cotton □ Spun cotton □ Tencel □ Modal □
   Any other □
   If synthetic, kind of fibre used :
   Cotton blend □ Nylon □ Polyester □
   Any other □
4. Whether the consumer makes any complaints about the performance of arm pad ?
   Yes □ No □
   If yes, mention what ?
   Bad odour □ Texture □
   Poor after few washes □ Any other □
5. Whether the consumers need any special finish to arm pad ?
   Yes □ No □
6. Is there any antibacterial finished arm pad available in market ?
   Yes □ No □
   If yes, what type of finishes given to the available arm pad ?
   Natural □ Synthetic □
7. Do you observe any herbal antibacterial finished arm pad available in market?
   Yes □ No □
8. Type of material used for cushion covers.
   Cotton □ Cotton blend □ Satin □ Silk □ Any other □
9. Is there any special finish to cushion covers available in market ?
   Yes □ No □
10. Whether the consumers need any special finishes on cushion covers ?
    Yes □ No □
11. Is there any herbal mosquito repellent finished cushion covers available in market ?
    Yes □ No □
APPENDIX – V
INTERVIEW SCHEDULE TO ELICIT INFORMATION FROM THE CONSUMER ABOUT ARM PADS

1. Do you aware of the arm pads?
   Yes □ No □

2. Did you comfort with the design of the products
   Yes □ No □

3. How often do you use the arm pads?
   Regular □ Occasionally □ Rare □

4. Are you feel comfort with the existing are
   Yes □ No □

5. Are you aware of the different type of fabrics used for arm pads?
   Yes □ No □

6. Do you thing the available product have durability?
   Yes □ No □

7. Are you aware of the different type of finishes applied on the arm pads?
   Yes □ No □

8. If yes, what type of finish do you preferred for arm pads?
   Herbal □ Chemical □

9. Did you afford the products?
   Yes □ No □

10. Are you satisfied with the existing products?
    Yes □ No □
1. Do you aware of any mosquito repellent products in the market?
   Yes ☐  No ☐

2. If yes, which type of finishes are available?
   Herbal ☐  Chemical ☐

3. Did you prepare the herbal finished cushion covers for mosquito repellent?
   Yes ☐  No ☐

4. Are you come across any skin problem while using chemical repellent?
   Yes ☐  No ☐

5. Repellent products are affordable?
   Yes ☐  No ☐
# APPENDIX – VII
## SAMPLES

<table>
<thead>
<tr>
<th>Cotton Yarn</th>
<th>Tencel Yarn</th>
<th>Modal Yarn</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>AG₁</td>
<td>BG₁</td>
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## APPENDIX – VIII
PROFORMA USED FOR WEAR STUDY FINDINGS

### FINDINGS OF THE WEAR STUDY ON ARM PADS

(N : 100)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Rating Scale</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Comfort</td>
<td>Absorbency</td>
<td>Durability</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>G</td>
<td>F</td>
<td>E</td>
</tr>
<tr>
<td>Herbal finished</td>
<td></td>
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<tr>
<td>Cotton</td>
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</tr>
<tr>
<td>Tencel cotton</td>
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</tr>
<tr>
<td>Modal cotton</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Plasma treated herbal finished</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Tencel cotton</td>
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<tr>
<td>Modal cotton</td>
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</tr>
</tbody>
</table>

E – Excellent ;  G – Good ; F - Fair

### FINDINGS OF THE WEAR STUDY ON CUSHION COVERS

(N : 100)

<table>
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<th>Rating Scale</th>
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<td>Durability</td>
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<td>E</td>
<td>G</td>
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<td>E</td>
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<tr>
<td>Plasma treated herbal finished</td>
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<td>Modal cotton</td>
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E – Excellent ;  G – Good ; F - Fair