

ODOUR REPELLANT CHARACTERISTICS OF SOCKS FABRIC

A PROJECT REPORT

Submitted by

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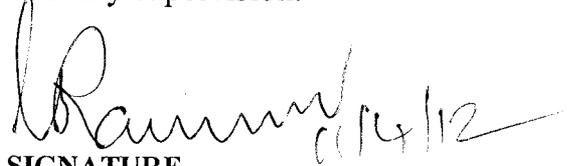
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ABSTRACT

The foot is one among the heaviest producers of sweat in the body. A socks helps to absorb this sweat and draw it to areas where air can evaporate the perspiration. Socks are designed to ease chafing between the foot and footwear, protect footwear by absorbing perspiration and dead skin, lost from the foot, keep the foot warm and soak up sweat from the foot if sweaty. Foot odor is the type of body odor that affects the feet of humans and is generally considered to be an unpleasant smell. It creates a perfect environment for certain bacteria to grow and produce bad-smelling substances.

Foot is also the result of wearing shoes and/or socks with inadequate air ventilation for many hours. Because human feet are densely covered with sweat glands, perspiration of the feet can combine with surface bacteria to produce odor. Thus antimicrobial agent was used to kill or inhibit the growth of microorganisms such as bacteria, fungi, or protozoan's that produces odor.

Hence an attempt was made to control the foot odor causing bacteria on socks by using natural antimicrobial agent. Gallnut (*Quercus infectoria*) was chosen as the natural antimicrobial agent which controls all the foot odor causing bacteria, *Staphylococcus aureus*, *Escherichia Coli*, *Propionibacterium Acnes*, *Brevibacterium linens* and *Staphylococcus epidermidis*,

Socks were knitted with two different combinations of yarns like cotton/nylon and 100% bamboo. The gallnut extract was prepared and applied on the knitted fabrics using dyeing technique.

Assessment of antimicrobial activity of treated knitted fabrics was carried out against the foot odor causing bacteria except *Brevibacterium linens*. And the zone of inhibition were identified. Finally, a Comparison was made between all the samples and the results indicated that 100% bamboo treated fabrics shows more zone of inhibition against all the odor causing bacteria.

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CHAPTER-1
INTRODUCTION

CHAPTER 1

INTRODUCTION

Foot odor is a type of body odor that affects the feet of humans and is generally considered to be an unpleasant smell. The main cause is foot sweat. Sweat itself is odorless, but it creates a perfect environment for certain bacteria to grow and produce bad-smelling substances. Bacteria are naturally present on our skin. Foot odor is also the result of wearing socks with inadequate air ventilation for many hours. Because human feet are densely covered with sweat glands, perspiration of the feet can combine with surface bacteria to produce odor. Hair on the feet, especially on the toes, may contribute to the odor's intensity by adding increased surface area in which the bacteria can thrive.

When socks directly contact the feet, their composition can have an impact on foot odor. Polyester and nylon are common materials used to manufacture socks, but provide less ventilation than does cotton when used for the same purpose. Wearing polyester or nylon socks may increase perspiration and therefore may intensify foot odor. Because socks absorb varying amounts of perspiration from feet, wearing shoes without socks may increase the amount of perspiration contacting feet and thereby increase bacterial activities that cause odor.

Bacteria responsible for the odor generation from the sweat are *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Propionibacterium acnes* and *Escherichia coli*.

Hence the aim of the project is to compare the antibacterial treated socks with 100% bamboo socks which are untreated. The natural agent selected for

foot odor environment should inhibit the growth of microorganism generated from foot.

1.1 OBJECTIVES

Main focus of this project work is controls odor in socks using natural antimicrobial agent. The main objectives of this work are:

1. To develop an economical and odor control socks applied with natural antimicrobial agent.
2. To identify the odor causing bacteria which are present in the foot.
3. To identify the suitable antimicrobial agent that inhibits all the foot odor causing bacteria.
4. To knit socks with the combination of cotton/nylon and 100%bamboo using socks knitting machine.
5. To extract gallnut using soxhlet apparatus.
6. To dye the fabric using extracts gallnut with various temperatures and % of dye.
7. To compare the antimicrobial activity of knitted fabric samples. To develop an economical and odor control socks applied with natural antimicrobial agent.
8. To identify the odor causing bacteria which are present in the foot.
9. To identify the suitable antimicrobial agent that inhibits all the foot odor causing bacteria.
10. To knit socks with the combination of cotton/nylon and 100%bamboo using socks knitting machine.
11. To extract gallnut using soxhlet apparatus.
12. To dye the fabric using extracts gallnut with various temperatures and % of dye.

CHAPTER-2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 SOCKS

A sock is a knitted or woven type of hosiery for enclosing the human foot. The foot is one among the heaviest producers of sweat in the body, able to produce over a pint of perspiration per day. A sock helps to absorb this sweat and draw it to areas where air can evaporate the perspiration. Socks are designed to ease chafing between the foot and footwear, protect footwear by absorbing perspiration and dead skin, lost from the foot, keep the feet warm and soak up sweat from the foot if sweaty. The different types of socks available are business socks, casual socks, sports socks, children's socks, ladies socks (Joyce Smith & Norma Pitts 1983).

2.1.1 Materials Used In Socks

Socks come in a variety of fibers and fiber combinations. Commonly used fibers include cotton, wool, nylon, acrylic, polyester, olefin, and spandex. Occasionally, luxury fibers such as silk, linen, cashmere, or mohair will be blended for softness, but this adds to the cost.

Natural fibers are absorbent. The presence of cotton and wool helps absorb perspiration. Wool absorbs up to 30% of its weight in moisture before feeling "wet," making it a desirable choice in winter—but once the fabric becomes saturated and moist, it feels cold to the wearer.

The term "Natural Blend Cotton" is used on the label of many socks. These socks have a high content of cotton (60%) with smaller amounts of synthetics, usually nylon or spandex, for reinforcement or support. Occasionally, linen, a natural fibre, is knitted into the toe of socks for reinforcement. Linen is a

relatively strong fiber and adds durability as well as absorbency and comfort. Silk socks are usually quite smooth and absorbent. They make a good layer next to the skin, but are not very durable.

Synthetic fibres, particularly nylon, are strong and make an excellent choice for socks which commonly receive hard wear. Besides durability, synthetic fibres add shrink resistance. Socks may be 100% nylon or reinforced at the toe and heel with this durable fiber.

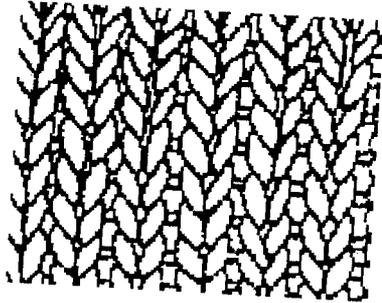
Acrylic fibers are long wearing but also add a cushiony softness and bulk to socks made from them. Acrylic fibres are commonly found in socks for casual wear. Olefin fiber has become important for outdoor sport socks. Olefin fibres do not absorb moisture; however, both olefin and acrylic have wicking ability. Acrylic and olefin socks are often worn next to the skin, with a wool or cotton sock over them to absorb moisture.

Stretch fibres, including spandex, elastic or rubber, are present in many socks. They help socks stay up and hug the leg and foot. Spandex is used extensively to provide support in the ankle, calf, and arch areas, especially in sport socks. These socks stay in place and increase blood circulation.

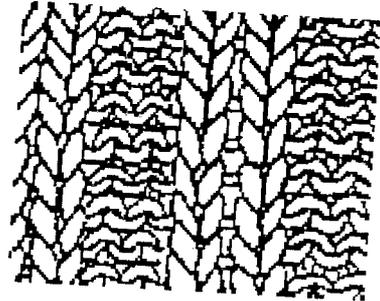
2.1.2 Knit Structure of Socks

Socks are knitted, giving them stretch and the ability to conform to the foot and leg. Generally, a stockinette or plain knit stitch is used in the foot area and a rib stitch is used in the leg area (though some socks are made totally of rib stitch). The rib stitch is very stretchy, with the ability to return to shape. As both the stockinette and rib stitches are simple knit constructions, the stitch can ravel out if a yarn is broken. Toe seams placed high over the toe are usually more comfortable than those at the end of the toe. Both the toe and heel areas should be smooth; otherwise irritation could occur during wear.

Stockinette



Rib Stitch



2.1.3 Socks Sizes

Adult Shoe Size	Order Sock Size	Calf Size	Total height from floor to just below knee	Finished Sock Length
Ladies 4- 5	Small	12"	14"	8.5"
Ladies 6-7	Medium	13"	15"	9"
Ladies 8-9	Large	14"	16"	9.5"
Ladies 10-11	X-Large	15"	17"	11"
Men's 8-9	Small	14"	16"	10"
Men's 9-10	Medium	15"	17"	11"
Men's 10-11	Large	16"	17.5"	11.5"
Men's 12-14	X-Large	17.5"	18"	12"

2.1.4 Antimicrobial Socks

2.1.4.1 Bamboo socks

Bamboo fibres have good antimicrobial properties, which make it more suitable for socks. Bamboo fibre has natural functions of anti-bacteria, bacteriostatic and deodorization. Even after fifty times of washing, bamboo fibre samples still possess excellent function of bacteriostatic. Its test result shows over 70% death rate after bacteria being incubated on bamboo fibre samples. This natural fibre is hypoallergenic, absorbent and fast-drying. It is naturally antibacterial and will not hold odor. Like other natural fibres, it allows the body to breathe as the samples absorb the sweat from the body. It is also the most sustainable of the natural fibres. Because of its natural antibacterial properties, it needs no pesticides. It is also 100% biodegradable. The characteristics of bamboo socks are as follows:

- It is more absorbent than cotton.
- It possesses a property called bamboo Kun that makes it naturally antibacterial.
- Its cashmere like softness gives great comfort to the wearer.
- Its porous fibres comfortably wicks moisture away from skin.

2.1.4.2 Coconut socks

Coconut socks are not exactly made from 100% cotton, they use “cocona” fibres, which are derived from coconut shells and infused with activated carbon from the water filter industry. Coconut socks have ability to control odor. And silver is one of the ingredients used along with activated carbon. Each molecule of activated carbon in the fabric is claimed to have a huge amount of surface area, which helps to pull moisture from the skin while it absorbs odors. The characteristics of Coconut socks are as follows:

- Sweat elimination
- Evaporative control

- Odor resistance
- Control of micro-bacterial growth
- UV protection and longevity.

2.1.4.3 Silver nanoparticles embedded socks

Six brands of socks impregnated with odor-fighting silver nanoparticles were chosen and soaked individually in one-half liter of distilled water with no detergent for one hour and then analyzed the effluent with electron microscopy. Each socks contains up to 1360 μg of silver. After washing all the six socks, 650 μg of silver as both ionic and colloidal forms was released. Thus the silver nanoparticles intended to control odor release in the wash.

2.2 FOOT ODOR

2.2.1 Sweat

Perspiration also called sweating or sometimes transpiration is the production of a fluid, consisting primarily of water as well as various dissolved solids (chiefly chlorides), that is excreted by the sweat glands in the skin. There are two types of sweat glands in the skin that is eccrine glands and apocrine glands.

Eccrine glands are distributed over most of the body, but occur in greatest density on the palms of the hands, soles of the feet, in the axillae (armpits), and on the forehead. Apocrine glands are present in hair follicles such as on scalp, armpits, breast and groin.

Eccrine sweat glands are involved in thermoregulation. These glands, controlled by the sympathetic nervous system, cool the skin by secreting water when body temperature rises. Apocrine glands on the other hand secrete a fatty sweat directly into the tubule of the gland. Under emotional stress, the wall of the tubule contracts and the sweat is pushed to the surface of the skin where the bacteria present in skin begin breaking the components of sweat.

Thus sweat produced by both these glands are odorless but when it appears on the skin, within an hour the bacteria which is alive on the skin breakdown the sweat and produces body odor.

From the above literature it is clear that the odor causing organisms on the foot is generated by sweat. One way to inhibit the bacteria is by applying antibacterial agents on yarn used to produce socks. (www.health.readvivek.com/Sweating-And-BodyOdor.html)

2.3 BACTERIA

A bacterium is a single-celled organism which can only be seen through microscope. Bacteria come in different shapes and the sizes are measured in micro-meter (which is a millionth part of a meter). Bacteria are found everywhere and in all types of environment.

2.3.1 Odor Causing Bacteria

Brevibacterium is a genus of bacteria of the order Actinomycetales. They are Gram-positive soil organisms. It is the sole genus in the family Brevibacteriaceae. *Brevibacterium linens* are ubiquitously present on the human skin, where it causes foot odor.

Staphylococcus epidermidis is a very hardy microorganism, consisting of non-motile Gram-positive cocci, arranged in diplococcic, two cells next to each other. It forms white raised colonies approximately 1–2 mm in diameter, after overnight incubation, and is non-hemolytic on blood agar. It is a catalase-positive, coagulase-negative, facultative anaerobe that can grow by aerobic respiration or by fermentation (although some strains may not ferment).

Propionibacterium acnes species are inhabitants of the skin and are

usually nonpathogenic. As a result, they are common contaminants of blood and body-fluid cultures. These species are slow-growing, nonsporulating, gram-positive anaerobic bacilli and require at least 6 days for growth in culture.

Escherichia coli (commonly abbreviated *E. coli*; is a Gram negative rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms (endotherms). Most *E. coli* strains are harmless, but some, such as serotype O157:H7, can cause serious food poisoning in humans, and are occasionally responsible for product recalls. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K, and by preventing the establishment of pathogenic bacteria within the intestine.

Staphylococcus aureus is a facultatively anaerobic Gram positive coccus, which appears as grape like clusters when viewed through a microscope, and has large, round, golden-yellow colonies, often with homolysis, when grown on blood agar plate. *Staphylococcus* is the bacterial family staphylococcaceae which includes three lesser known genera, *gamella*, *micrococcus* & *salinicoccus*. *Staphylococcus aureus* is catalase-positive, so is able to convert hydrogen peroxide (H_2O_2) to water and oxygen, which makes the catalase test useful to distinguish staphylococci from enterococci and streptococci.

2.3.2 Classification of Bacteria

Gram stain classification

I Gram Positive Organisms

a) Aerobic, Gram-positive cocci

Staphylococcus aureus, *Staphylococcus epidermidis*,
Staphylococcus sp. (Coagulase-negative) *Streptococcus pneumonia* (Viridans group) *Streptococcus agalactiae*
(group B) *Streptococcus pyogenes* (group A) and

Enterococcus sp.

b) Aerobic, Gram-positive rods
Bacillus anthracis, Bacillus cereus, Bifidobacterium
bifidum, Lactobacillus sp. Listeria monocytogenes,
Nocardia sp. Rhodococcus equi (coccobacillus)
Erysipelothrix rhusiopathiae, Corynebacterium diphtheriae
and Propionibacterium acnes. (Pyatkin and Krivoshein
1987)

c) Anaerobic, Gram-positive rods
Actinomyces sp. Clostridium botulinum, Clostridium
difficile, Clostridium perfringens and Clostridium tetani.

d) Anaerobic, Gram-positive cocci
Peptostreptococcus sp.

II Gram Negative Organisms

a) Aerobic, Gram-negative cocci
Neisseria gonorrhoeae, Neisseria meningitides and
Moraxella catarrhalis.

b) Anaerobic, Gram-negative cocci
Veillonella sp.

c) Aerobic, Gram-negative rods

i) Fastidious, Gram-negative rods
Actinobacillus actinomycetemcomitans,
Acinetobacter baumannii, Bordetella pertussis,
Brucella sp. Campylobacter sp. Capnocytophaga sp.
Cardiobacterium hominis, Eikenella corrodens,
Francisella tularensis, Haemophilus ducreyi,
Haemophilus influenza, Helicobacter pylori,
Kingella kingae, Legionella pneumophila,

Pasteurella multocida, Enterobacteriaceae (glucose-fermenting Gram-negative rods) *Citrobacter* sp. *Enterobacter* sp. *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus* sp. *Salmonella enteritidis*, *Salmonella typhi*, *Serratia marcescens*, *Shigella* sp. *Yersinia enterocolitica* and *Yersinia pestis*.

- ii) Oxidase-positive, glucose-fermenting Gram-negative rods. *Aeromonas* sp. *Plesiomonas shigelloides*, *Vibrio cholera*, *Vibrio parahaemolyticus* and *Vibrio vulnificus*.
- iii) Glucose-nonfermenting, Gram-negative rods
Acinetobacter sp. *Flavobacterium* sp. *Pseudomonas aeruginosa*, *Burkholderia cepacia*, *Burkholderia pseudomallei*, *Xanthomonas maltophilia* or *Stenotrophomonas maltophilia*.
- d) Anaerobic, Gram-negative rods
Bacteroides fragilis, *Bacteroides* sp. *Prevotella* sp. and *Fusobacterium* sp.
- e) Gram-negative spiral
Spirillum minus.

2.4 NATURAL ANTIBACTERIAL AGENT

Natural antibacterial agent is any natural compound that can destroy or inhibit the growth of bacteria in concentrations. The details pertaining to natural antibacterial agent that can inhibit the bacteria from sweat is given below:

2.4.1 Gallnut

2.4.1.1 History

Quercus infectoria is a small tree from four to six feet high, crooked and shrubby-looking, with smooth and bright-green leaves, most abundant in Asia Minor, and extends to middle Asia.

The gall is an excrescence developed by a puncture or wound made in the bark (foliaceous or cortical parts) of plants by an insect *Cynips gallae tinctoriae* for the purpose of depositing their eggs, along with acrid liquor, in the wound thus made. The irritation thereby produced gives rise to an influx of the juices of the plant to the wounded part, and an excrescence is formed, which is termed as gall.

Here the insect usually undergoes its transformations: the egg produces the larva which feeds on the juices of the plant, and is changed into the pupa. This afterwards becomes the perfect insect (imago), and perforating the gall, produces a small, round hole, through which it escapes from its prison-house.

Those galls from which the insect has escaped are commonly larger, colored, and less astringent and they are termed as nutgalls. The nutgalls vary in their size, shape, weight and quality of surface in different countries.

2.4.1.2 Description

English name: Oak Galls

Botanical name: *Quercus Infectoria*

Ayurvedic name: Maju or Majuphul

Family: Cupuliferae

Parts used: Galls

2.4.1.3 Composition

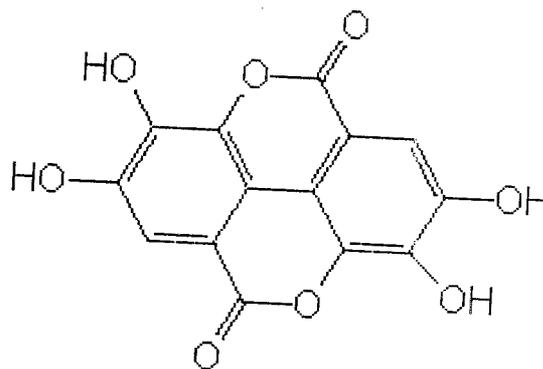
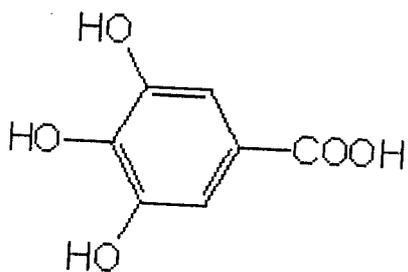
Gallnut (nutgalls) contains the highest naturally occurring level of tannin (gallotannin), from 50% to 75%. It also consists of gallic acid (2-3%), and ellagic acid (2%), and glucose, starch, and etheric fats (3%).

2.4.1.4 Structure of tannin

Tannins have a great structural diversity, but are usually divided into two basic groups: the hydrolyzable type and the condensed type. Hydrolyzable tannins include the commonly-occurring gallic acid and the ellagic acid. The chemical structure of Gallic and ellagic acid is shown below.

As their name infers, hydrolyzable tannins are readily degraded into smaller molecules. It reacts with proteins to produce the typical tanning effect. Medicinally, this is important for treatment of inflamed or ulcerated tissues. They also contribute most of the astringent quality that is noted when drinking tannin-containing beverages.

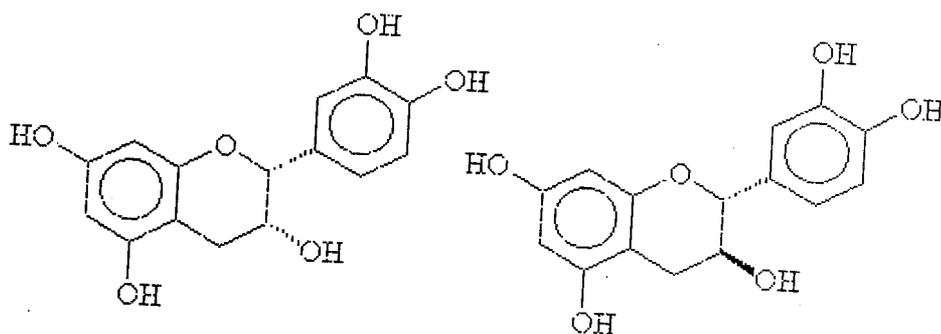
The condensed tannins, also known as proanthocyanidins, are much more resistant to decomposition and merely yield polymers or precipitates when acidified. The basic monomer of condensed tannins is epicatechin and catechin; these are then extended by the successive addition of similar phenol units to produce polymers (Polyphenols).



Gallic acid

Ellagic acid

Although both types of tannin have been used to treat diseases in traditional medicine, the hydrolyzable tannins have long been considered official medicinal agents in Europe and North America. They have been included in many pharmacopoeias, in the older editions in particular, and are specifically referred to as tannic acid. These were recommended for treatment of inflammation and ulceration, including topical application for skin diseases and internal use for intestinal ulceration and diarrhea.



Epicatechin

Catechin

2.4.1.5 Properties of tannin and its basic groups

Tannic acid is readily soluble in water and very sparingly soluble in ether. The aqueous solution precipitates solution of gelatin with yellowish white color, and the per salts of iron with bluish-black color. When burned with free access of air it leaves no residue.

Gallic acid is generally of a pale fawn color. It requires about one hundred parts of cold water for solution, but dissolves in three parts of boiling water. The aqueous solution gives no precipitate with solution of isinglass, but with a persalt of iron it gives a black one. When dried at 212°C the crystalline acid loses 9.5 % of its weight. Burned with free access of air, it leaves no residue.

Ellagic acid, appears in the separated state as a white crystalline powder, and differs from tannin and gallic acid in being almost insoluble alike in alcohol, ether, and water. It does not exist in ready form in galls, but originates in the action of atmospheric oxygen upon their tannin.

2.4.1.6 Studies on antibacterial properties

Many bacteria have become antibiotic-resistant. This increases the importance of ayurvedic drugs. A study has been conducted to find the activity of different extracts of *Quercus infectoria* galls against dental pathogens *Streptococcus epidermidis*, *Brevibacterium*, *Propionibacterium*, and *Escherichia coli*.

The cup plate method was used in anti-bacterial activity of extracts at concentration of 200mg/ml against dental pathogens. Minimum inhibitory concentration (MIC) values of most effective extracts against the most susceptible bacteria were determined using a two-fold serial micro dilution method. Methanol extract showed maximum antibacterial activity against all the bacteria (Prabhat et al 2009).

2.4.2 Clove Oil

2.4.2.1 History

Cloves (*Syzygium aromaticum*) are the aromatic dried flower buds of a tree in the family Myrtaceae. Cloves are native to Indonesia and used as a spice in cuisines all over the world. The English name derives from Latin *clavus* 'nail' as the buds vaguely resemble small irregular nails in shape. Cloves are now harvested primarily in Indonesia, Madagascar, Zanzibar, Pakistan, and Sri Lanka; they are also grown in India under the name Lavang. The clove tree is an evergreen which grows to a height ranging from 8-12 m, having large square leaves and sanguine flowers in numerous groups of terminal clusters. The flower buds are at first of a pale color and gradually become green, after which they develop into a bright red, when they are ready for collecting. Cloves are harvested when 1.5–2 cm long, consist of a long calyx, terminating in four spreading sepals and four unopened petals which form a small ball in the center.

2.4.2.2 Origin of clove oil

Clove oil is an essential oil extracted from different parts of clove (*Syzygium aromaticum*) plant. It can be extracted from the leaves, stem and buds of the plant, thus possible to obtain three types of clove oil as given below

- Bud oil is derived from the flower-buds of *S. aromaticum*. It consists of 60-90% eugenol, eugenyl acetate, caryophyllene and other minor constituents.
- Leaf oil is derived from the leaves of *S. aromaticum*. It consists of 82-88% eugenol with little or no eugenyl acetate and minor constituents.
- Stem oil is derived from the twigs of *S. aromaticum*. It consists of 90-95% eugenol, with other minor constituents.

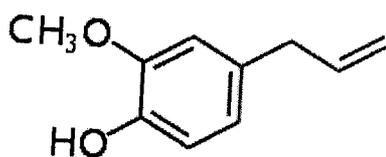
2.4.2.3 Chemical compounds

Eugenol comprises 72-90% of the essential oil extracted from cloves.

Other important essential oil constituents include acetyl eugenol, beta-caryophyllene, vanillin, cratogenic acid, tannins, gallotannic acid, methyl salicylate; the flavonoids eugenin, kaempferol, rhamnetin, and eugenitin; triterpenoids like oleanolic acid, stigmasterol and campesterol; and several sesquiterpenes.

2.4.2.4 Eugenol

It is the active element in clove. Eugenol is an allyl chain-substituted guaiacol (2-methoxyphenol). It appears as a clear or pale yellow oily liquid. It is slightly soluble in water and soluble in organic solvents. It is responsible for most of the characteristic aroma of cloves.



Eugenol

It is found in insect attractants as well as UV absorbers. Since it is an antioxidant it is useful in the manufacture of plastics and rubbers, besides being beneficial when ingested in moderate amounts.

2.4.2.5 Medicinal properties of clove oil

Clove oil can be used for acne, bruises, burns and cuts, keeping infection at bay and as a pain reliever. It helps with toothache, mouth sores, rheumatism and arthritis. It is beneficial to the digestive system, effective against vomiting, diarrhea, flatulence, spasms and parasites as well as bad breath. Clove oil is valuable for relieving respiratory problems, like bronchitis, asthma and tuberculosis. It is also of use for skin problems - especially for skin sores and leg ulcers and as an insect repellent.

2.4.2.6 Antibacterial activity of clove oil

A study was carried out on antimicrobial activity of some herbal oils against common food-borne pathogens. In this study screening was carried out on ten herbal oils, which were purchased from the local market of Meerut region to study their role as inhibitors of food-borne pathogens. Of the ten essential oils, only cinnamon and clove oil exhibited a broad range of antimicrobial activity, followed by peppermint and Eucalyptus oil against all the tested bacteria *Staphylococcus aureus* (CCSUB1), *Staphylococcus epidermidis* (CCSUB2), *Bacillus subtilis* (CCSUB3), *Bacillus cereus* (CCSUB4), *Bacillus* sp. (CCSUB5), *Listeria monocytogenes* (CCSUB6), *Micrococcus luteus* (CCSUB7), *Escherichia coli* (CCSUB8), *Pseudomonas aeruginosa* (CCSUB9) and *Klebsiella* sp. (CCSUB10). Cinnamon oil exhibited the lowest minimum inhibitory concentration (MIC) of 1.25% (v/v), followed by clove oil with an MIC of 2.5% (v/v). These oils therefore possess potential to be used as food bio preservatives (Charu Gupta et al 2008).

2.4.3 Mango Leaf

2.4.3.1 Description

Botanical name: *Mangifera indica* L.

Plant part used: Leaves of *Mangifera indica* L.

Content Standardized: Mangiferin, 60~80%

Color: Yellow to Light Yellow

2.4.3.2 Phytochemical constituents

Mangifera indica has the following phytochemical constituents:
2-octene, Alanine, Alpha-phellandrene, Alpha-pinene, Ambolic-acid, Ambonic-acid, Arginine, Ascorbic-acid, Beta-carotene Beta-pinene, Carotenoids, Furfurol, Gaba, Gallic-acid, Gallotannic-acid, Geraniol, Histidine, Isoleucine, Isomangiferolic-acid, Kaempferol, Limonene, Linoleic-acid, Mangiferic-acid,

Mangiferine, Mangiferol, Mangiferolic-acid, Myristic-acid, Neo-beta-carotene-b, Neo-beta-carotene-u, Neoxanthophyll, Nerol, Neryl-acetate, Oleic-acid, Oxalic-acid, P-coumaric-acid, Palmitic-acid, Palmitoleic-acid, Pantothenic-acid, Peroxidase, Phenylalanine, Phytin, Proline, Quercetin and Xanthophylls.

2.4.3.3 Nutritional benefits

Tender leaves of mango tree possess anti-diabetic properties. In some of the islands of the Caribbean, the leaf decoction is taken as a remedy for diarrhea, fever, chest complaints, diabetes, hypertension and other ills. A combined decoction of mango and other leaves is taken by mothers after childbirth.

2.4.3.4 Antibacterial activity of mango leaf

Antimicrobial activity was assessed by inhibition diameters which were found to range from 9–15.5 mm for the three extracts against all the bacterial strains tested and inhibition growth curves which showed the extracts as first acting within the first 20 min after which a steady state (bacteriostatic) was attained and maintained throughout the testing time (360 min) with a significant difference ($p < 0.05$) from the negative control. The minimum inhibitory concentrations for the extracts were later determined by two fold serial dilutions method and they ranged from 36.2–18.2 mg/ml against all the strains. The extracts were then subjected to reversed-phase HPLC to identify and quantify the polyphenol mangiferin which was found to be the abundant compound in the extracts at 100 $\mu\text{g/ml}$ with no significant difference ($p < 0.05$) in quantity among the three extracts.

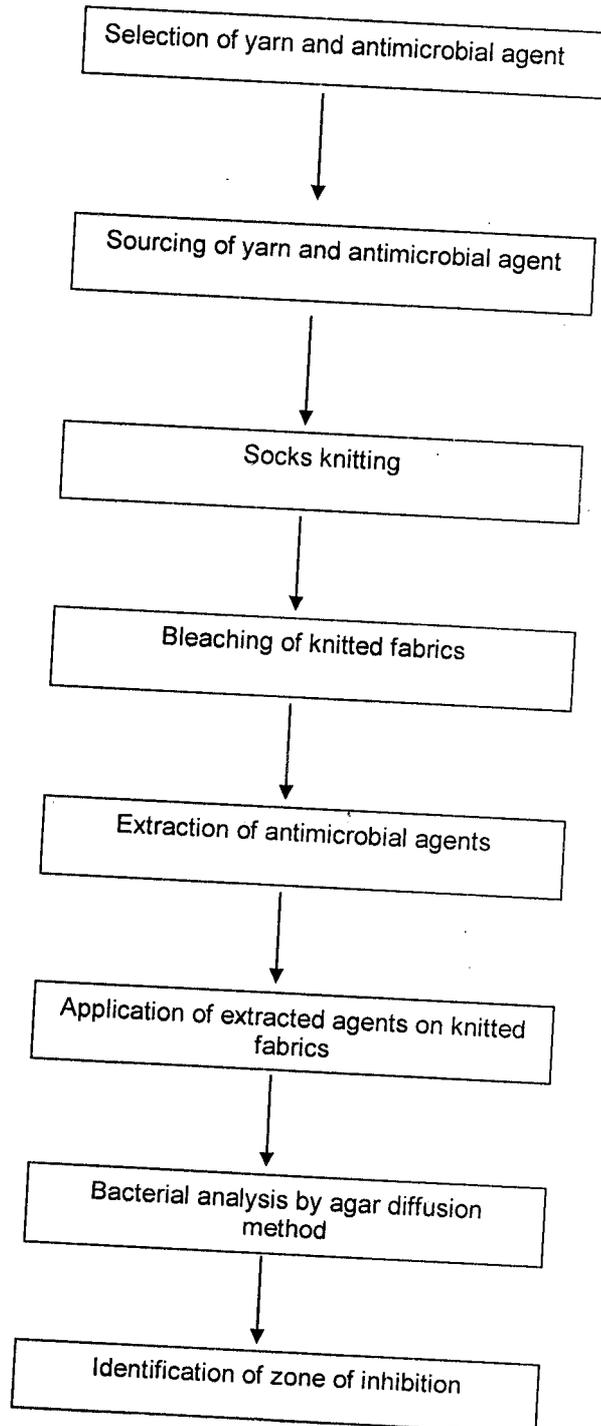
The active components of leaves of *Mangifera indica* L. were extracted using cold water and organic solvents (acetone and methanol) and were tested against *Staphylococcus aureus*, *Streptococcus pyogenase*, *Streptococcus pneumonia*, *Bacillus cereus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Salmonella typhi* and *Shigella flexnerri* using the

agar well diffusion method. Both the acetone and methanol extracts inhibited the growth of gram positive bacteria, with acetone extract exerting more activities on all the gram positive bacteria with zone of inhibition between 15 - 16 mm, and a gram negative bacterium *Salmonella typhi* giving 14mm at 250 mg/ml. Whereas, water extract was not active on any of the bacterial pathogens tested at any of the concentration of the extract used (Doughari et al 2008).

CHAPTER-3
MATERIALS
&
METHODOLOGY

CHAPTER 3

MATERIALS AND METHODOLOGY



3.1 Materials used

In this study three different kinds of yarns were used and their parameters are shown in the table 4.1. Sourcing of material was done on the basis of market analysis.

Table 3.1 – Specification of the yarns

Sample No.	Type of yarn	Count of the yarn
1	Cotton	30s
2	Bamboo	30/1
3	Nylon	70/2

Natural antimicrobial agent namely Gallnut (*Quercus infectoria*) seeds supplied by M/s. Kannan Herbals, Coimbatore, India were used. Acetone supplied by Bio processing laboratory in KCT Bio-Technology Department.

The details of the bacteria used in the study are as follows. *Staphylococcus aureus*, *Escherichia coli*, *propionibacterium acnes*, and *Staphylococcus epidermidis*, were the clinical isolates obtained from R&D Bio-technology, Coimbatore, India.

3.2 Methods

3.2.1 Application of Extract from Gallnut Powder

The extract prepared from gallnut powder containing active biological components was used on cotton fibre. Solvent extraction technique using Soxhlet apparatus (Carl Conrad 1944) was employed for the purpose.

3.2.2 Procedure adopted for extraction

5g of gallnut powder was taken in the thimble and 100 ml of acetone as supplied was added to the extraction flask. The complete assembly of the apparatus was kept on a heating mantle and its temperature was adjusted in such a way that the solvent siphons over once in every 3 to 4 min interval. The extraction was continued for two hours. After turning off the heat, the thimble

was replaced with a condenser and heating continued till the volume of the solution in the flask was reduced to 15ml. Then the solutions in the flask were transferred to a beaker and fix that beaker to the Rotary Evaporator until the acetone evaporates completely, then collect Gallnut alone in the conical flask.

3.2.3 Application of Extracted Powder

0.5g of fibre was immersed in solutions having required concentrations of extracted powder and 2%w/v sodium chloride for 1h at room temperature with occasional stirring. The liquor to material ratio used was 50: 1. Various concentrations of the extracted powder used were 4%, 12%, 16%, 20% and 28% w/v. The treated materials were taken out, squeezed and air dried without subjecting them to washing process.

3.2.4 Knitting process

The yarns were knitted using socks knitting machine in three combination and their parameters are shown in the table 4.2.

Sample No.	Material Structure	Wales Per Inch(WPI)	Course Per Inch(CPI)
1	Cotton/Nylon single jersey	21	27
2	100% Bamboo single jersey	21	20

3.2.5 Bleaching process

Bleaching is carried out using hydrogen peroxide to remove the natural coloring matter and to obtain white material and facilitate the production of pale and bright shades on the materials.

3.2.6 Procedure for bleaching process

Hydrogen peroxide is a universal bleaching agent and is used extensively for the bleaching of the materials. Hydrogen peroxide solutions are rapidly decomposed by many metals especially copper the use of which should be avoided. Stainless steel is suitable, iron, lead and aluminum can also be used in presence of silicate. The materials was treated with 3% (owm) hydrogen peroxide, 2% (owm) sodium silicate and 1% (owm) sodium hydroxide at 90°C for two to three hours using MLR 1:20. Sodium silicate is an excellent stabilizer for peroxide but in continuous process it forms insoluble component on the surface of the bleaching equipment and causes abrasion of the cloth comes in contact with it. Therefore, disodium hydrogen phosphate is preferred to silicate in such processing.

3.2.7 Application of extracted agents on knitted fabrics

The fabrics were cut into required pieces, required Gallnut (20%) and sodium chloride (20g/l) is taken based on the own weight of the material. Clean the vessel and take the required water in 1:50 MLR ratio with 40°C temperature. After the bath reach 40°C add the Gallnut to the water and stirred it well for 45 minutes. Then put the fabric inside the vessel, after 20 minutes add sodium chloride for more fixation of Gallnut into fabric. The fabric were taken from the bath after 45 minutes and then wash it in the hot wash and cold wash, fabric was dried using drier machine to remove moisture in the fabric.

3.2.8 Estimation of Antibacterial Activity

The fabric with the diameter of $2\text{cm} \pm 0.1\text{cm}$ was taken for the analysis. Both the sides of samples were pre sterilized under ultra violet radiation for 15 minutes. Sterile bacteriostasis agar was dispensed in sterile petridishes. Broth cultures (24 hours) of the test organisms were used as inoculums. Using sterile cotton swab, the test organisms (*Staphylococcus epidermidis*, *Propionibacterium acnes*, *Escherichia coli* & *Staphylococcus aureus*) were swabbed over the

surface of the agar plate. Pre sterilized samples were placed over the swabbed agar surface by using sterile spatula and forceps. After placing the samples, all the plates were incubated at 37°C for 18 to 24 hours. After incubation the plates were examined for the zone of bacterial inhibition around the fabric sample. The size of the clear zone was used to evaluate the inhibitory effect of the fabric.

3.2.9 TESTING AND OBSERVATIONS OF SOCKS

4.1- FABRIC TENSILE STRENGTH

TABLE-
FABRIC TENSILE STRENGTH – SOCKS FABRIC

S.NO	COURSE DIRECTION		WALES DIRECTION	
	TENSILE STRENGTH (N/mm ²)	BREAKING FORCE (kgf)	TENSILE STRENGTH (N/mm ²)	BREAKING FORCE (kgf)
1	69	42	62	45
2	58	36	59	40
MEAN	60	38	59	41

4.2-ABRASION RESISTANCE

TABLE -
ABRASION RESISTANCE - SOCKS FABRIC

S.NO	INITIAL WEIGHT(gms)	FINAL WEIGHT(gms)	WEIGHT LOSS(%)	ABRASION RESISTANCE(%)
1	15	14	20.7	112.78
2	15	14	20.7	110.78
MEAN	15	14	20.7	108.78

CHAPTER-4

RESULTS

&

DISCUSSION

CHAPTER 4

RESULT AND DISCUSSION

This chapter deals with test results obtained in this project work and the inference made based on these results. In this study, oil based natural antibacterial agent i.e., gallnut was chosen to treat the cotton/nylon, 100% bamboo.

5.1 Antimicrobial activity of Cotton/Nylon

Figure 5.2 shows the zone of inhibition obtained for the gallnut used for the treatment of cotton/nylon sample when tested for their antibacterial activity.

Table 4.2 shows the width of inhibition obtained for the above samples.

Table 5.2 Width of inhibition obtained for Gallnut treated Cotton/Nylon samples

S.No	Name of the microbe	Zone of inhibition (mm)
1.	<i>Escherichia coli</i>	0
2.	<i>Staphylococcus aureus</i>	24
3.	<i>Staphylococcus epidermidis</i>	17
3.	<i>Propionic acnes</i>	18

The values indicate that antibacterial activity of cotton/nylon fabric against different bacteria.

5.2 Antimicrobial activity of 100% Bamboo Treated

Figure 5.2 shows the zone of inhibition obtained for the gallnut used for the treatment of bamboo sample when tested for their antibacterial activity. Table 4.2 shows the width of inhibition obtained for the above samples.

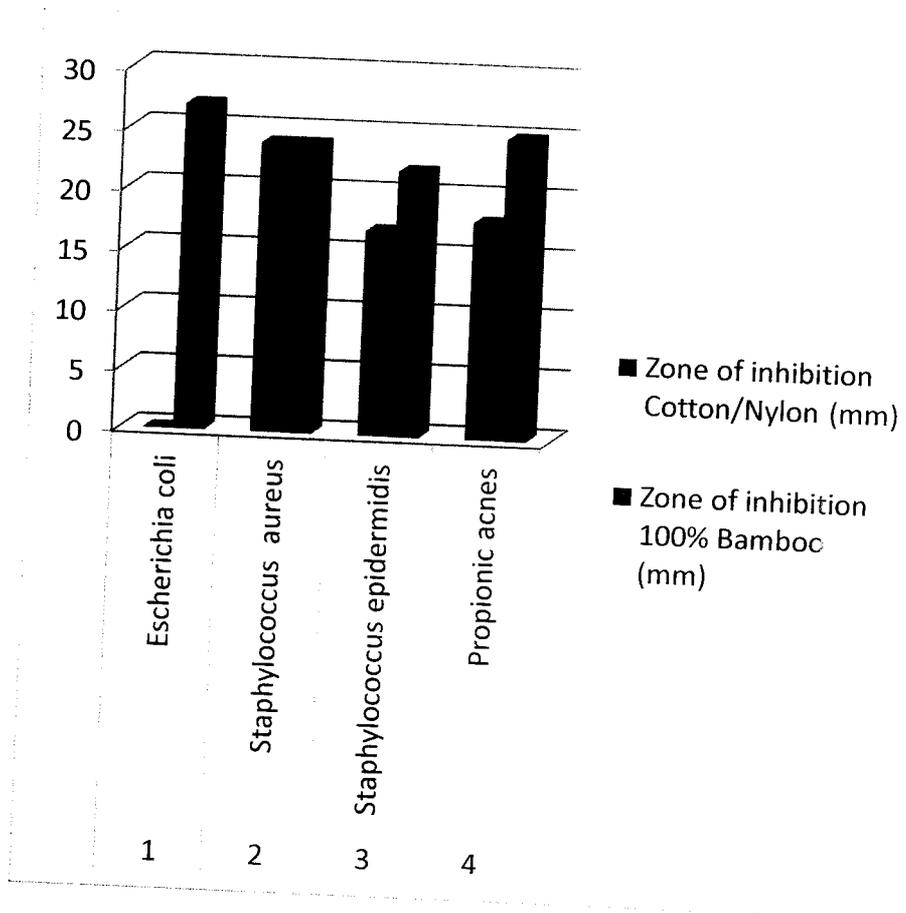
Table 5.2 Width of inhibition obtained for 100% bamboo treated samples

S.No	Name of the microbe	Zone of inhibition (mm)
1.	<i>Escherichia coli</i>	27
2.	<i>Staphylococcus aureus</i>	24
3.	<i>Staphylococcus epidermidis</i>	22
3.	<i>Propionic acnes</i>	25

The values indicate that antibacterial activity of bamboo fabric against different bacteria.



5.3 COMPARISON OF ZONE OF INHIBITION BETWEEN COTTON/NYLON AND 100% BAMBOO FABRIC



CHAPTER-5
CONCLUSION

CHAPTER 5

CONCLUSION

From the study conducted on 'Development of odor control socks', the following conclusions is drawn.

1. The antibacterial agent, gallnut, chosen for the treatment of cotton/nylon and 100%bamboo treated and untreated fabrics.
2. Gallnut treated 100%bamboo knitted fabric is found to have good antibacterial activity against the bacteria Escherichia coli, Staphylococcus aureus, Staphylococcus epidermidis and propionic acnes grow in sweat.
3. Presence of higher amount of gallnut in the bamboo knitted fabric gives improved zone of inhibition in the antibacterial test carried out using Agar diffusion method.
4. Extract from the gallnut powder applied on the cotton/nylon and bamboo untreated are found to have less Antibacterial activity compared to bamboo treated fabric.
5. Higher concentrations of the extract from gallnut powder applied are found to give better antibacterial activity.
6. Bamboo treated fabric shows good antibacterial activity against all Bacteria because It is more absorbent than cotton and Possesses Natural antibacterial property.

The above findings indicates that there is a good scope to produce odor control socks using natural antibacterial agents to protect foot from odor causing bacteria produced in the multi-environment condition to which they are exposed to.

CHAPTER-6

REFERENCES

CHAPTER 6

REFERENCES

1. Kumar S, "Formulation and Evaluation of Herbal drugs for Anti-acne activity", 2004.
2. Samuelsson G, "Drugs of natural origin", Sweden: Swedish pharmaceutical press; 1999.
3. Bhattacharjee SK, "Handbook of Medicinal Plants". India: Pointer Publishers; 2001.
4. Dar MS, Ikram M, Fakouhi T, "Pharmacology of Quercus infectoria", J Pharm Sci 1976;65:1791-4.
5. Kaur G, Hamid H, Ali A, Alam MS, Athar M, "Antiinflammatory evaluation of alcoholic extract of galls of Quercus infectoria", J Ethnopharmacol 2004;90:285-92.
6. Ebling FJG, "Acne Vulgaris", Text book of Dermatology, 6th edition.1998, 3: 552-554.
7. Gulbrandson, "Buying Socks", Fargo, ND: North Dakota Cooperative Extension Service,1992.
8. SITRA - Research Report – "Development of Bandages Using Bamboo Fibres", Vol 52, August 2007.
9. H Mucha, D Hoter and M Swerev, "Antimicrobial Finishes and Modifications Melliland International", May 2002, vol 8, pp 148-151.
10. Gettings RL and BL Triplett, "A New Durable Antimicrobial Finish for Textiles", AATCC Book of Papers, 1978, Pg. 259-261.
11. www.health.readvivek.com/Sweating-And-BodyOdor.html
12. <http://www.organiclyhatched.com/Bamboonursingpads/bamboonp.html>
13. www.ccsf.edu/Departments/Biology/ctoebe/bactcell.htm

CHAPTER-7
APPENDICES