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An overview of Functional Bioactive Substances obtained from Rosmarinus Officinalis and Psidium Guajava Plant Extracts and their Applications in Medical Textiles

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Abstract: *The medical textile is one of the fastest growing areas in current world. It is a part of technical textiles. In recent years, finishing play an important role to protect people against harmful pathogens, an antimicrobial textile has been urbanized. The synthetic antibacterial agents are developed, but it is harmful to humans and the environment. In order to provide potential solutions to synthetic antibacterial agents, the natural antibacterial agents are developed to protect humans from harmful microorganisms. Rosemary and guava leaves are rich sources of natural nutrients and bioactive compounds such as Terpenoids, Polyphenols, Tannins, Flavonoids, Anthraquinones, Glycosides, Carotenoids, Ursolic acid, Carnosol, Oleanolic acid, Alkaloids and Saponins as functional components with latent medicinal, biological, and pharmaceutical properties of human healthcare and hygienic applications. The present review discusses the herbal plant potential of different bioactive compounds present in rosemary and guava leaves and its prominent features that are mainly responsible for the antioxidant, anti-inflammatory, anti-tumor, anticancer, and antibacterial properties present in rosemary and guava plants and their applications in the area of medical textiles. It can also be used for biological, pharmaceutical, food, healthcare and hygienic textile applications.*

Key Words: ***Rosmarinus officinalis*, *Psidium Guajava*, Bioactive substances, Antibacterial activity, Antioxidant activity, Finishing method.**

1. INTRODUCTION

Medical textile is one of the most popular and rapidly growing markets across the world and variety of textiles products with medical applications are being consumed by the consumers [7]. The finishing of textiles plays a major role in medical field. Antibacterial finishing of textile products gives protection from bacteria. The synthetic antibacterial agents are developed to protect the human being from bacterial damage and help to prevent bacterial infections. The synthetic antibacterial agents like quaternary ammonium compounds, triclosan, regenerable N-halamine and peroxyacids, metals and metal salts such as silver, zinc, Copper. It is harmful to humans and environment. So, the alternative solution to rectify the problem is natural herbal extracts are used as an antibacterial agent in medical field.

Rosmarinus Officinalis is commonly termed as rosemary. It is an evergreen, perennial shrub, of the Lamiaceae family [17]. It is also known for its exclusive aromatic odour and grown in the Mediterranean region. Rosemary is now cultivated around the world for its properties like medicinal, aromatic and ornamental purposes. The leaves are about 3.5cm long and 4mm wide, which appear dark green on the topside and pale grey green on the underside. The bioactive compounds present in rosemary are flavanoids, phenolics, oleanolic acid, carnosol, ursolic acid, and terpenoids [8]. The herb has functional properties like antibacterial, wound healing, anti-inflammatory, antioxidant, anti-cancer, and antiseptic activities [8]. The herb is rich in minerals such as vitamin A, vitamin C, iron, calcium, and potassium. Its flowers are very small and colour ranges from white, pale blue, dark blue to violet. Rosemary is a most effective herb used in the food industry. In cooking, the wide variety of dishes likes salads, stews, casseroles, soups, and savoury foods.

Psidium Guajava commonly termed as guava. It is a tropical tree, which belongs to Myrtaceae family. The native region of this plant is tropical America. It grows even in drought conditions and high temperature, widespread in summers. It spreads to the height of 6 to 25 feet. The bioactive compounds present in guava are flavanoids, carotenoids, polyphenols [16], tannins, terpenoids, saponins, alkaloids, glycosides and anthraquinones [3]. The herb has functional properties like antibacterial, wound healing, anti-cancer, antioxidant, anti-inflammatory, and anti-allergic activities [5]. It is also used for treating wound healing, cold and cough, weight loss, improves eyesight, prevent hair loss, reduces acne, improves skin texture, and manage diabetes. The herbal extract is extracted from rosemary and guava leaves using a soxhlet apparatus, super critical fluid extraction method, ultrasound extraction method and steam distillation extraction method. The finishing method suitable for applying the herbal extract on the textile materials such as a direct application method, microencapsulation method and cross-linking method to evaluate the biological property. The Thin Layer Chromatography (TLC) techniques, FTIR spectroscopy analysis, Gas Chromatography Mass Spectroscopy (GCMS) and High-Pressure Liquid Chromatography (HPLC) were used for analyzing the bioactive compounds and functional groups present in the herbal extract. The antibacterial property was tested using the agar well diffusion method and parallel streak method. The aims of the study are to investigate the functional properties of rosemary and guava extract for medical, biological, pharmaceutical, food, healthcare and hygienic textile applications.

2. BIOACTIVE COMPOUNDS DERIVED FROM ROSEMARY AND GUAVA LEAVES

2.1 Phenolics

The largest group of phytochemicals is most widely distributed in the plant kingdom. The three most important groups of dietary phenolics are phenolic acid, polyphenols and flavanoids. Phenols (C_6H_5OH) are considered a most simple class of natural compounds. Phenolic compounds are a complex and large group of chemical constituents that are present in plants [21]. They are secondary metabolites and plays an important role as defending compounds.

2.2 Phenolic acid

The term phenolic means phenols that possess one carboxylic acid functional group. Naturally occurring phenolic acids contain two distinct carbon frameworks, they are hydroxybenzoic and hydroxycinnamic structures. Hydroxycinnamic acid compounds are formed as simple esters with hydroxyl carboxylic acids and glucose [21]. These compounds have the property to fight against oxidative damage leading to various diseases like degenerative, cardiovascular, cancer and inflammation. Mainly tumour cells, including leukaemia cells have high levels of reactive oxygen species (ROS) than other normal cells and particularly they are sensitive to oxidative cells.

2.3 Flavanoids

Flavanoids are polyphenolic compounds that are ubiquitous in nature. According to chemical structure they differ into isoflavones, flavones, flavonols, flavanones, catechins, chalcones and anthocyanidins. Around 4000 flavanoids have been found out, in which most of the flavonoids are occurring in vegetables, fruits, beverages (coffee, wine, beer, tea, fruit drinks). The flavanoids have been increased considerably in recent times due to their potential benefits in human health [21]. It is responsible for producing higher antioxidant, anti-allergic, anti-platelet, antitumour, and anti-inflammatory activities.

2.4 Tannins

Tannins are difficult to define chemically and it contains diverse oligomers and polymers. Tannins are a heterogeneous group of high molecular phenolic compounds which have the capacity to form reversible and irreversible complex substances such as nucleic acids, proteins, alkaloids, minerals and polysaccharides [21]. Based on their structural characteristics they are divided into four major groups such as complex-tannins, gallo-tannins, ellagi-tannins and condensed-tannins.

2.5 Alkaloids

The name alkaloids derived from "Alkaline" and it is used to define any nitrogen containing bases. They are natural products that contain heterocyclic nitrogen atoms. They are synthesized by a large number of organisms like bacteria, animals, plants and fungi [21]. Its form salts with acid. Alkaloids are numerous and vary in molecular structures due to which their normal classification is difficult.

2.6 Saponins

Saponins are group of secondary metabolites present widely in the plant kingdom. Chemically saponins are group that include compounds such as triterpenoids, steroid alkaloids and glycosylated steroids. The glycosylated steroids are divided into two main types, namely furostan and spirostan derivatives [21]. The main triterpene aglycone is a derivative of oleanane. The carbohydrate part consists of one or more sugar containing arabinose, xylose, galactose, glucose, rhamnose or glucuronic acid link with aglycone. Saponins with one sugar molecules attach to the C-3 position are called monodesmoside saponins and saponins with two sugar molecules attached to C-3 and C-22 is called a bidesmoside saponins.

2.7 Oleanolic acid

Oleanolic acid is a pentacyclic triterpene, found in non-glyceride. Pentacyclic triterpene are naturally occurring compounds which are widely distributed in plants [21]. This natural compound possesses anti-inflammatory properties. Triterpenoids possesses antioxidant properties. Oleanolic acid exhibits both pro and anti-inflammatory properties based on their chemical structure.

2.8 Carnosol

It is a natural occurring phenolic diterpene found in herbal plants like rosemary. It has been present in rosemary leaf extract for attaining high antioxidant activity. About 90% of activity contains carnosic acids. The carnosol has multi medicinal properties like antimicrobial, anticancer, and anti-inflammatory. It promotes the synthesis of nerve growth factor in glial cells [21].

2.9 Ursolic acid

It is a ubiquitous triterpenoid in the plant kingdom. It is an integral part of the human diet and also a medicinal herb. It has possessed antioxidant and antitumour activities [21]. It is also used to treat cancer cells.

2.10 Terpenoids

Terpenoids correspond to largest and most diversified class of chemicals among the myriad compounds produced in plants. Plants have these metabolites have a wide variety of basic functions in growth and developments and also for protection in the biotic and abiotic environment. It is used in food, chemical and pharma industries. Terpenoids are divided into monoterpenes, diterpenes, sesquiterpenes and triterpenes [21]. Terpenoids structure is biologically active and used to treat many diseases especially malaria. They have properties like antimicrobial, anti-inflammatory, anticancer, and antitumour activities.

2.11 Carotenoids

Carotenoids are a group of natural occurring pigments with many attributes for human health. They are essential compounds in all photosynthetic organisms. Due to its antioxidant and photo protect they belong to isoprenoids

and they have eight isoprene units. It plays a significant role in improving human health and reducing the risk of chronic disease. The main properties are anticancer, antioxidant, and antimicrobial activities [21].

2.12 Glycosides

They occur in a wide variety of natural occurring substances in which carbohydrate portion consists of one or more sugar or uronic acid [21]. They occur in plant parts like flowers, fruit pigment etc. They are used as antibiotics in the field of medicine.

2.13 Anthraquinones

Anthraquinones are aromatic compounds. There are 79 naturally occurring anthraquinones are identified and it includes rhein, cascarin, physcion, catenarin and emodin. Anthraquinones, are also known as anthracenediones. It is an important member of the quinone family and has a large structural variety of compounds among the polyketide group [21]. Anthraquinones produces secondary metabolites in insects, plants, lichens and fungi as a glycoside. They have properties like antioxidant, antimicrobial, antitumour and anti-inflammatory activities.

3. BIOLOGICAL PROPERTIES ATTAINED FROM ROSEMARY AND GUAVA LEAVES

3.1 Anti-bacterial activity

Antibacterial activity is used to identify the resistivity of herbal extract against the bacteria. In this study one-gram positive bacteria (*Staphylococcus aureus*) and one-gram negative bacteria (*Escherichia coli*) was used to evaluate the antibacterial activity. The zone of inhibition is measured in mm. The main antibacterial compounds in the herbal extracts are terpenoids, anthraquinones, carotenoids, and carnosol [21]. There are many methods and standards are available for measuring the anti-bacterial activity. They are Agar diffusion (EN ISO 20645), Agar dilution (ATCC 29213), Micro dilution (ISO 20776-2006) and Semi-automated methods (ASTM D7454).

3.2 Anti-inflammatory activity

Inflammation is considered to be an intricate biological response of vascular tissues to harmful stimuli such as pathogens, damaged cells, or irritants. It can help us to protect against physical wounds, poison and other injuries. Its defense system is also called as short-term inflammation. The short-term inflammation can destroy micro-organism, infections, remove irritants and maintain normal physiological functions. The long-term inflammation may cause rheumatic arthritis and asthma [21]. This inflammatory process is triggered by many biological and chemical aspects which include cytokines, pro-inflammatory enzymes, low molecular weight compounds. The main anti-inflammatory compounds in the herbal extracts are carnosol, anthraquinones, terpenoids, oleanolic acid, and flavonoids.

3.3 Anti-tumour activity

Antitumour activity is mainly influenced by the effect of Interferon beta (IFNβ) on proliferation, and cell cycle indirectly by activating the immune system. The three different mechanisms for antitumour activity are stimulation of fatal differentiation of altered cells, anti-proliferative and alteration of antigens on the surface of tumor cells that can lead to the induction of the immune system [21]. The main antitumour compounds in the herbal extracts are anthraquinones, ursolic acid and flavonoids.

3.4 Anti-oxidant activity

Antioxidants can help human health against damage by ROS (Reactive oxygen species). An antioxidant can be widely defined as a substance that inhibits oxidative damage to the target molecule [21]. The main characteristic of antioxidant is the ability to trap free radicals. The antioxidant compounds such as polyphenols, flavonoids and phenolic acids. Scavenge free radicals like hydro peroxide or lipid peroxyl and peroxide. The main antioxidant compounds in the herbal extracts are carotenoids, anthraquinones, ursolic acid and flavonoids.

3.5 Anti-cancer activity

Anticancer activity is the effect of the chemical, synthetic, natural and biological agents to reserve, and prevent carcinogenic progression. Several man-made agents are used to cure cancer disease as they are toxic [21]. The natural products from medicinal plants are extracted to cure various tumours like lymphoma, leukaemia, sarcoma and carcinoma. The main anti-cancer compounds in the herbal extracts are carnosol, terpenoids and carotenoids.

4. EXTRACTION METHODS OF BIOACTIVE COMPOUNDS

4.1 Soxhlet extraction of herbal leaves

The extraction means separation of medically active part of the plant using appropriate solvents (methanol) through standard procedures. The soxhlet apparatus working on infusion method principle. The bioactive compounds present in the herbal plant leaves are extracted using soxhlet apparatus. The soxhlet extraction apparatus consists of thimble, condenser, siphon tube, bypass tube, reservoir and water-cooling system. In the soxhlet extraction method, finely ground powder of the herbal leaves was filled in the thimble chamber using non-woven bag. The bottom flask was filled with methanol, which will be heated, vapourized through the thimble. When the condenser flask condenses the herbal plant using methanol solvent and drip back. The extraction process was carried out at boiling temperature of 40˚C [19]. When the liquid contains (solvent + herbal extract) reaches the siphon arm and settled at the bottom flask. The extraction chamber containing herbal extract was kept at 30°C in the rotary vacuum evaporator to eliminate the solvent present in the final extracts. The final concentrate present in the extraction chamber was kept at 4°C to become fine powder and it is dissolved in methanol for further process.

4.2 Super critical fluid extraction method

The extraction process is used to separate one compound from other compounds by using solvents like acetone, methanol, ethanol and water. In this method of extraction, super critical fluid act as a solvent with other co-solvent to enhance the ability to separate the elements. The rosemary

and guava leaves are taken in the form of cell column. In super critical fluid extraction, CO_2 acts as a super critical fluid, ethanol and methanol acts as a co-solvent. The different components of the super critical fluid are pressure controller, a pressure cell, heating, cooling system, collecting vessel and pump. The liquid is modified in supercritical form and then passes to extraction cell and diffuse into a solid matrix of the sample and then dissolve the extracted material [19]. The dissolved material will be swept away from cell column at low pressure and extracted material settled out at the bottom. Carbon dioxide can be recycled at the end. The pressure and temperature conditions should be maintained about 200-300 bar and 45-55˚C.

4.3 Ultra sound extraction method

The solid sample of 1.5 mg is taken in ultrasound apparatus. The ultrasound apparatus consists of ultrasound generator, digital timer, water tank, and rotary gear [19]. The temperature is 40-50˚C and time is 1-2 hours. After that, the material was filtered by vacuum evaporator.

4.4 Steam distillation extraction method

This process is suitable for natural aromatic compounds using temperature sensitive compounds which degrade at high temperature. The steam distillation apparatus consists of steam generator, dielectric heater, condenser, and collection tank [19]. The dried leaf material of 25mg is distilled in 300ml water. The process time should be 3-4 hours at boiling temperature of the solvent. After distillation, water and volatile compounds are separated by using methyl chlorate.

5. IDENTIFICATION OF BIOACTIVE COMPOUNDS

5.1 Thin Layer Chromatographic technique (TLC) analysis of herbal extract

The herbal plant extracts were subjected to the analysis of different bioactive compounds using TLC techniques. The extract was applied on activated TLC plates with the help of capillary tube at a 1/2 inch apart from the lower edge of TLC plate, and the plate was kept in a developing chamber containing suitable solvent system for specific time until the developing solvent reaches top of the upper edge of TLC plate[2]. The plate was taken out from developing chamber, dried and solvent front is marked by lead pencil. Compound bands/spots visualized on TLC chromatoplate by using suitable spraying reagent for the presence of specific compounds. The visualized spots of the components in the chromate plate are marked and the *Rf* value *of* each spot is calculated by the formula,

$$Rf = \frac{\text{Distance travelled by the sample (cm)}}{\text{Distance travelled by the solvent (cm)}}$$

5.2 Fourier Transform Infrared Spectroscopy analysis of herbal extract

It is a typical infrared scan and it is generated in the mid-infrared region of the light spectrum. In order to analyze the functional groups, present in the herbal powder. Take 2g of the powdered herbal extract and 5g of potassium bromide was used as raw material. Then it is filled in the mortar with the ratio of 1: 6. The mixtures are ground thoroughly by using the pestle so that the large crystal is broken down to smaller ones [9]. Then lay the mixture in the pellet die compactly and pressure is applied to form pellets. The formed pellet is carefully removed from the die and placed in FTIR sample pellet holder. The FTIR spectroscopy is ready to locate the functional groups present in the herbal extract using IR radiation [20]. The result is produced in the form of spectral graph with respect to wavenumbers.

5.3 Gas Chromatography and Mass Spectroscopy (GC-MS) analysis of herbal extract

The Gas Chromatography /Mass Spectrometry technique is known for detecting the volatile and non-volatile compounds present in the herbal extract. The bioactive components present in the herbal extract are separated and detected quantitatively and it also has a detector used for providing clear information about the structure of each bioactive component present in the extract. Therefore, the compounds present in the extract can be identified with respect to the retention time based on mass spectrum. The column used in the GC/MS instrument is a capillary column, whereas in the GC instrument uses packed column. The capillary column is a simple long glass tube with a small internal diameter. The stationary phase is bonded to the interior of the glass capillary and thereby eliminates the packing [9]. Depending on the type of separation different column might have bonded phases of different characteristics can be used.

After the separations of the bioactive components present in the extract, the ion trap detector has pure compounds. By passing the stream of gas over a beam of electron accelerated at an energy level of 70eV, these compounds are ionized by electron impact. This energy is used to form ions by stripping away the electron and it may break some of the bonds present in the compound. Different populations of ions will have a different amount of internal energy. Some of the molecules will not fragment but will be ionized, forming a molecular ion. The parent ion or molecular ion has the same atomic mass as the neutral molecule. It is the highest mass peak in the spectrum. There are many ions formed which have enough energy to fragment, smaller mass ions are formed and a neutral which is not detected. By using the same energy electrons to ionize the compounds, the resulting mass spectra is highly reproducible. Likewise, libraries of mass spectral data have been generated so that unknown compounds can be identified by finding and matching the mass spectra [9]. Different class of bioactive compounds has some fragmentation character which will be helpful in identifying unknown compounds. The eluted compounds were identified by comparing the mass spectral data with the standard data available in the library of National Institute of Standards and Technology [15].

5.4 High Performance Liquid Chromatography (HPLC) analysis of herbal extract

The high-performance liquid chromatography is a widely used robust and versatile technique for isolation of natural products. The modern instrument comprises an auto

sampler or manual injection valve, a solvent delivery pump, an analytical column, a recorder or a printer and a guard column. The chemical separations can be accomplished by using the different migration rates given a particular column and mobile phase of certain compounds. The extent of separation of bioactive compounds was determined by the stationary and mobile phase [14]. In general, the identification and separation of bioactive compounds can be done using isocratic system.

Purification of the compound using HPLC is the process of separation and extraction of the required compound from other compounds and contaminants. There is a characteristic peak or each and every compound under certain chromatographic conditions. Based on what needs to be separated, the chromatographer may choose the conditions like flow rate, suitable detector, mobile phase and columns to get an optimum separation of particular compounds [14].

Identification of any compounds by HPLC is done using a detector. It must be selected first and optimal detection setting and a separation assay must be developed. The parameter of this assay should form a clean peak of the known sample from the chromatographer. The peak should have a reasonable retention time so that it can be identified and it should be separated well enough from extraneous peaks at the detection level. UV detectors are popular among all other detectors as they offer high sensitivity. The main advantage is that majority of natural compounds encounter some UV absorbance [14] at low wavelengths (190-210 nm). Diode array detector coupled with mass spectrometer and liquid chromatography coupled with mass spectrometer (MS) is a powerful technique for the analysis of complex botanical extract. Therefore, the HPLC along with MS facilitates accurate and quick identification of chemical compounds in medicinal herbs.

The dried, powdered plant will be initially treated in such a way that the compound is efficiently liberated into the solution. An organic solvent like methanol can be used for the initial extraction and followed by maceration, the solid materials are removed by decanting off the whole extract by filtration. Then the filtrate is concentrated and injected into the HPLC machine for separation of bioactive compounds. The usage of guard columns is necessary in the analysis of crude extract in order to protect the lifespan of the analytical columns [14].

6. FINISHING METHODS OF HERBAL EXTRACT ON TEXTILE MATERIALS

6.1 Direct application method of herbal extract

The direct application method is easy to coat the substance directly onto the fabric by dipping the fabric in the solution of herbal extract or by applying the solution of herbal extract by direct coating by brush or hand or floating knife blade. The blade can be of different angles and profiles which affects the coverage of material on the fabric. This process can be effective depending on the viscous nature of the herbal extract solution [15]. Once the fabric is directly coated with the herbal extract solution and finished using citric acid as a cross-linking agent to fix the herbal extract on the surface of the fabric without easy removal. Around 8 to 10% citric acid is used based on the fabric weight. Padding is done using pneumatic padding mangle at a pressure of 3 psi to get an herbal extract pickup of 100% on weight of fabrics. Drying and curing were carried out in a curing chamber at 80°C for 5 minutes.

6.2 Microencapsulation process of herbal extract using ionic gelation process

Microencapsulation is done using rosemary and guava leaf herbal extracts, which are used as the core material and sodium alginate as the wall material. Ten grams of sodium alginate powder are allowed to swell for 15 min in 100 ml of hot water. To get this mixture, 50 ml of hot water was added and stirred for 15 min maintaining the temperature between 40ºc to 50ºc. Two grams of core material (*Rosmarinus Officinalis* and *Psidium Guajava* herbal extracts) are slowly added under stirring condition. Stirring continues for another 15 min and then 8 g of citric acid is added [18]. Then, 0.2M calcium chloride is added with 100ml water to prepare the solution for formation of microencapsules [15]. The stirring is stopped and the mixture of herbal extract and sodium alginate was filled in the syringe and beads were formed by pouring the mixture in the calcium chloride solution. The microcapsules present in the collection bath was repeatedly washed with isopropyl alcohol followed by drying at 45ºc for 12hrs.

6.3 Cross- linking method of finishing herbal extract on textile materials

One gram of *Rosmarinus Officinalis* and *Psidium Guajava* herbal extracts will be mixed with 100 ml (120 gpl concentration) non-formaldehyde based resin and 2.0 g sodium chloride (NaCl) added as a catalyst [15]. Cotton fabric will be dipped in the resin solution and padded through a pneumatic padding mangle. The treated fabric will be dried at 80ºc for 5 min and cured at 150ºc for 3 min.

7. EVALUATION OF ANTIBACTERIAL ACTIVITY

7.1 Antibacterial activity of herbal extract powder using Agar Well Diffusion method (NCCLS-1993)

For extraction, 2g of dry powder from the given herbal extract powder was taken and mixed into 20ml of 90% methanol and 20ml of 90% ethanol separately for screening of the plants showing significant antibacterial activity against two organisms (*Escherichia coli* and *Staphylococcus aureus*). The containers were closed and kept for overnight (12 hours at room temperature) for proper dissolving of the compounds into the solvent. After an overnight incubation, the extracts were filtered through filter paper and evaporated to concentrate [13]. The concentrated extracts were tested to determine its antibacterial activity. The antibacterial activity of the different plant extracts was evaluated by the agar well diffusion method [12]. Sterile Muller-Hinton agar plates were prepared. The plates were allowed to solidify for 5 minutes and wells of 6 mm were punctured using a well borer. 0.1% inoculum suspension of *Escherichia coli* and *Staphylococcus aureus* were swabbed uniformly over the surface of the agar separately and the plates were incubated at 37°C for 24 hours. A zone of

inhibition around the well was measured in mm, after incubation and recorded.

7.2 Antibacterial activity of herbal extract finished fabric using Parallel Streak method (AATCC 147-1988)

The test specimens (control and finished fabric swatches) were cut into pieces (25mm x 50mm). A 50mm length permits the specimen to lay across 5 parallel inoculums streaks each of diminishing width from both 8mm to 4mm wide. Sterile AATCC bacteriostasis agar plates were prepared [1]. Using sterile 4mm inoculating loop, one loop full of test organisms (*Escherichia coli* and *Staphylococcus aureus*) was loaded and transferred to the surface of the agar plate by making five parallel inoculum streaks spaced 10 mm covering the central area of the petridish without refilling the loop. The test specimen was gently pressed transversely, across the five inoculums of streaks to ensure intimate contact with agar surface [10]. The plates were incubated at 37˚C for 18-24 hours. The inoculated plates were examined for the interruption of growth along the streaks of inoculum beneath the fabric and for a clear zone of inhibition beyond the fabric edge. The average width of the zone of inhibition around the test specimen was calculated in mm.

8. APPLICATIONS OF HERBAL EXTRACT IN VARIOUS INDUSTRIES

Rosemary extract is used to cure large number of diseases such as headaches, epilepsy, poor circulation, diabetes mellitus, respiratory disorders, eczema, stomach problems and inflammatory diseases [17]. The rosemary oil is used as a food additives and food preservatives in food industry. It is also used to make consumer products like soaps, creams, candles, and deodorants. Rosemary leaves are used to make the various dishes like stews, casseroles, salads, pasta and soups. The rosemary has rich source of aroma and it is mainly used in the perfume industry. The rosemary oil is used in aromatherapy. It is also used in cosmetic products like shampoo, cleansing products, hair conditioners, makeup, bath products, skin care lotions, suntan products, personal cleanliness items and shaving products. It is also used as herbal pesticides.

Guava is referred as 'apple of the tropics'. The leaves are used to prepare essence to cure the severe stomach pain. The various parts of guava are used for medicinal purpose. The guava leaf tea is used for the treatment of diarrhea, dysentery, diabetes mellitus, inflamed mucous membranes, digestive problems, edema, gout, hemorrhages, oral ulcers, gastroenteritis and gastritis, and hypertension. It improves liver damage, inflammation and locomotors coordination. The polyphenolic compounds of guava are used for the treatment of cancerous cells. It helps to prevent skin aging and improving texture and tone of skin.

The guava leaf powder acts as a natural preservative for the skin care cosmetic creams, ointments and lotions [6]. The guava extract is used to cure the infertility problems. It can increase the sperm quantity and quality of males. The guava hand sanitizer gel is produced by using the guava leaf extract and other compounds like alcohols and glycerin. It is used to prevent the bacterial infections by hand washing. Scurvy is a nutrition and dietary vitamin deficiency disease. The lack of vitamin C is the main cause of this disease. Guava is rich in vitamin C and it is used to cure the scurvy [4]. The antioxidant compounds of guava are used in cosmetics and health care products to protect the skin from environmental conditions.

In food industry the guava fruit is used to prepare pudding, cake, pie, sauce, butter, sherbet, marmalade, jam, jelly, chutney, relish, catsup, bakery, ice cream, pastes, pies, confections in fruit juices, popsicles and puree and several dairy products. Corrosion is occurring in all material, particularly steel. The inhibitors are used to slow down the corrosion. There are two types of inhibitors they are synthetic inhibitor and natural inhibitor. The synthetic inhibitor is expensive, toxic and harmful to the environment. The natural inhibitors are extracted from the plant source rich in tannin. Tannin is a polyphenolic compound has hydroxyl, carboxyl and other groups. It is non-toxic in nature. Guava leaves are rich in tannin (12-18%). The tannin is extracted from guava leaves and it is used as a natural inhibitor to slow down the corrosion in the steel [11]. The guava leaf extract is used as natural dye in textile processing industry to dyed cotton fabrics.

9. CONCLUSIONS

In this study, the selected herbs were extracted using soxhlet extraction apparatus, super critical fluid extraction method, ultrasound extraction method and steam distillation extraction method were assessed for biological properties. It has excellent bioactive compounds such as Terpenoids, Polyphenols, Tannins, Flavonoids, Glycosides, Anthraquinones, Ursolic acid, Carnosol, Oleanolic acid, Alkaloids, Carotenoids and Saponins were analyzed using TLC, FTIR, GCMS and HPLC methods. The direct application method, microencapsulation method and cross-linking method were used to treat the herbal extract on the textile materials. The antibacterial activity was assessed for both herbal extract and finished cotton fabric using the agar well diffusion method and parallel streak method. The synthetic antibacterial agents are harmful to humans and the environment. Therefore, the natural herbal extract is used as an antibacterial agent to overcome this problem and protect humans from harmful microorganisms. Such herbal extract can also be used for medical, biological, healthcare, pharmaceutical, food, and hygienic textile applications.

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