EXTRACTION, PHYTOCHEMICAL SCREENING AND COMPARISON OF THE DISINTEGRATING PROPERTIES OF EXTRACTS OBTAINED FROM NATURAL SOURCES AMONG THEMSELVES AND WITH MARKETED STARCH

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ABSTRACT

The discovery of natural drugs gave rise to medicinal plants, which have become popular because of their pharmacological properties. There are infections everywhere, and they flourish in the right circumstances that are determined by the nutrients, moisture, temperature, and pH that promote the development of pathogenic microorganisms on fabrics and surfaces. Antimicrobial coatings and agents may thus be the key to destroying microorganisms. The process of creating antimicrobial finishings, microorganisms, how they attach to natural and synthetic fiber, the impact of microbial growth, and the theory and mechanism behind medicinal plants' microbial activity are all examined in this review study. This study also includes advances of antimicrobial treated textiles employing different agents, extraction procedures, and qualitative and quantitative phytochemical assessments of antimicrobial activity.

Keywords: phytochemical screening, solvent extractions, textile finishing, antimicrobial agents, and qualitative and quantitative analysis.

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1. INTRODUCTION

Antibiotics play a vital role in fighting bacterial infections, but antibacterial resistance has caused havoc in the healthcare and pharmaceutical sector that accelerates socioeconomic losses [1]. Multidrug Resistance is said to increase by 10 million deaths per year by 2050 [1,2]. Biological screening, separation of the phytochemicals, and clinical trials of the medicinal plants have advanced over the years unfolding the secrets of ancient herbal remedies [3]. Traditional medicine is effective in dealing with diseases caused by bacteria or oxidative stress [4–6]. Natural compounds have been extensively explored for new drug discoveries [7] Humanity has always been fascinated by natural compounds from pre-biotic, microbial, plant, and animal sources. Extracts of different parts of plants contain bioactive compounds that fight against diseases such as alkaloids, steroids, tannins, glycosides, volatile oils, fixed oils, resins, phenols, terpenoids, and flavonoids [8] The phenolic phytochemicals from plants play a key role as

antimicrobial agents [6,9] Antimicrobial agents decay the protein components of the cell wall, disrupting the work of enzymes and DNA and RNA replication [10] Table 1 shows a selection of plants, their phytochemicals responsible for antimicrobial activity, and their applications.

Table 1. Representation of medicinal plant extracts and their applications.

Plant Name	Phytochemicals	Applications
Sutherlandia fructecens	Saponins, pinitols, flavonoids, triterpenoids, Cannavanine, cycloartane glycosides, flavonol glycosides, and aminobutyric acid [11].	Wound treatment, cancer treatment, diabetes, skin diseases, rheumatism, urinary tract infection, fever, gonorrhoea, kidney, and liver problems [11].
Eucomis autumnalis	Homoisoflavanones, terpenoids, and diben-α-pyrones [12].	Reducing fever, urinary diseases, stomach, lower backaches, and syphilis. *Eucomisautumnalis* issometimes used to induce labour [12].
Plumbago auriculata	Tannins, phenols, alkaloids, saponins, flavonoids, plumbagin, α-amyrin, capensisone, and diomuscinone [13].	Treating headaches, warts, skin infections, wounds, and fractures [13].
Catharanthus roseus	Vinblastine, deoxyvinblastin, vincoline, cathanranthamine, rosicine, leurosine, vindoline and vincristine [14].	Treating rheumatism, venereal diseases, skin infections, high blood pressure, and diabetes [15].
Aspalathus linearis	Spalathin, orientin, isoquercitrin, and luteolinhyperoside [15].	Treat insomnia, stomach cramps, allergies, and digestive problems as well as improve appetite [16].
Centella asiatica	Triterpenoids, centellose, medacassoside, triaponosides, flavonoid quercetin, rutin, kaempferol, patuletin, apigenin, polyacetylenes, phenolic acids, sterols [17].	Treating fever, leprosy, syphilis, tuberculosis, leprosy, asthma, epilepsy, mental disorder, and minor wounds. Consumed as a vegetable and used as a spice [17].
Sclerocarya birrea	Glucosides, steroids, glycosides, flavonoids, fatty oils, alkaloids, phenols, resins, calcium, and phosphorus [18].	Treating dysentery, rheumatism, malaria, and diarrhoea [18].
Hypoxis hemerocallidea	Rooperol, β-sitosterol [19].	Immune booster, purgative, and laxative tonic. Treat tuberculosis, urinary tract infection, infertility, cancer, diabetes, and wounds [19].
Galenia africana	Trihydroxyflavanone, trihydroxychalcone, dihydroxychalcone, trihydroxy-3-methoxychalcone [20].	Treat venereal sores, eye infections, asthma, tuberculosis, cough, wounds, skin infections and relieve toothache [20].

2. Textiles and Microorganisms

Textiles are carriers of microorganisms and are subjected to the growth of microorganisms, such as bacteria and fungi, depending on the food, acidic pH, temperature, time, oxygen, and moisture [11]. Bacteria interrelates with fibres in phases, from initial attachment onto fibres to the growth and damage to the fibres [12]. Cotton is one of the ideal natural fibre fabrics for the growth of pathogens than polyester. Neely [21]. has shown the survival of several gram-positive bacteria (Staphylococcus aureus, Enterococcus faecalis) on standard hospital fabrics made of 100% cotton clothing, 100% cotton terry towels, 60%/40% cotton/polyester-scrub suits and lab coats, and 100% polyester drape.

A study by Neely [21] showed the growth of bacteria within 48 h, most bacterial growth survived at least a day, and some survived more than 90 days. Natural fibre textiles are more prone to microbial growth and could lead to the spread of infections [14]. A study by Gupta [22] reports that the attachment of the bacteria onto the fabric is dependent on the characteristics of the fabric, the contact time of the microbe onto the fabric, surface roughness, and moisture retention for natural and synthetic fibres reacting differently to microbial growth [2]. Natural fibres are more prone to microbial attack because they retain water easily. Microbial growth on synthetic fibres like polyester is slower due to their polymer backbone [12].

3. Requirements, Modes of Antimicrobial Action of Antimicrobial Agents

The ideal antimicrobial treatment for textiles must be effective against a broad spectrum of pathogens but exhibit low toxicity to the user. It must be cost-effective, durable to launder, and not alter the quality or appearance of the textile [23]. A study by Gao et al., [24] reported that microbes are microscopic organisms that exist as unicellular, multicellular, or cell clusters. They consist of an outermost cell wall that constitutes polysaccharides. The cell wall maintains the integrity of cellular components and shields the cell from the extracellular environment. Beneath the cell wall is a semipermeable membrane that encloses intracellular organelles and multiple enzymes and nucleic acids. The enzymes are responsible for the chemical reactions within the cell, followed by the storage of nucleic acid genetic information of the organism. The purpose of antimicrobial agents is to destroy the cell wall or alter cell membrane permeability, denature proteins, inhibit enzyme activity, or inhibit lipid synthesis so that the cell does not survive.

The modes of antimicrobial action of antimicrobial agents define the existence of antimicrobial agents. The antimicrobial agents target mainly the cell wall, and cell membrane, denature protein, inhibit enzyme activity, and inhibit lipid synthesis. There are various classes of antimicrobial agents that possess different mechanisms of action against microbes. Table 2 shows the different antimicrobial classes, the mechanisms of action, and the activity spectrum, respectively [25]. Adapted with permission from Ref. [25]. 2014, Dr Patricia Tille.

Table 2. Representation of mechanisms of action of antimicrobial agents [25]. Adapted with permission from Ref. [25]. 2014, Dr Patricia Tille.

Antimicrobial Class	Mechanism of Action	Activity Spectrum
β-lactams	They inhibit cell wall synthesis by binding enzymes in peptidoglycan production	Gram-negative bacteria and gram-positive bacteria could differ with individual antibiotic
Aminoglycosides	Hinders the protein synthesis by binding 30S ribosomal subunits	Gram-negative bacteria and Gram-positive bacteria
Chloramphenicol	Inhibits the protein synthesis by binding 50S ribosomal subunits	Gram-negative bacteria and Gram-positive bacteria
Fluoroquinolones	Inhibits DNA synthesis by binding the DNA gyrase topoisomerase IV	Gram-negative bacteria and gram-positive bacteria, but it could differ with individual antibiotic
Glycylglycines	Inhibits the protein synthesis by binding 50S ribosomal units	A wide spectrum of gram-negative bacteria and gram-positive pecies
Ketolides	Inhibits protein synthesis by binding 50S ribosomal subunits	Gram-positive cocci including certain macrolide resistance strains and Gram-negative strains
Lipopeptides	Binding and disruption of cell membrane	Gram-positive bacteria including β-lactams and glycopeptides
Nitrofurantoin	The mechanism is unknown and may have bacterial enzyme targets and damaging DNA	Gram-negative bacteria and gram-positive bacteria
Oxazolidinones	Hinders the initiation of protein synthesis by binding 50S ribosomal subunits	Wide variety of Gram-positive bacteria including those resistant antimicrobial classes
Polymyxins	Disrupts cell membrane c	Poor activity against most Gram-positive bacteria. Gram-negative bacteria
Rifampin	Hinders RNA synthesis by binding DNA dependent, RNA polymerase	Gram-positive and certain Gram-negative bacteria
Streptogramins	Hinders the protein synthesis by binding two separate sites on the 50S ribosomal subunit	Gram-positive bacteria
Tetracycline	Inhibits protein synthesis by binding of 30S ribosomal subunit	Gram-negative bacteria and gram-positive bacteria and several intracellular bacterial pathogens
Sulfonamides	Hinders the folic acid pathway, binding the enzyme dihydropteroate synthase	Gram-negative bacteria and gram-positive bacteria
Trimethoprim	Hinders with the folic acid pathway by binding the enzyme dihydrofolate reductase	Gram-negative bacteria and gram-positive bacteria

Textiles are regarded as the only barrier between humans and pathogens. Plant-based extracts and materials provide an efficient and natural microbial resistivity. Antimicrobial textiles are essential in the apparel, commercial, and healthcare sector [26]. A study by Vastrad et al. [27] reported on the evaluation of total phenolic content and flavonoid content using leaf extracts (eucalyptus and lemongrass) with methanol, ethanol, chloroform, and distilled water extract indicated the potential of antimicrobial application of textiles. The antimicrobial agents and finishing on textiles may allow the re-use of face masks, and clothing, reducing PPE kits in health care, reducing domestic laundering that may lead to a reduction in water consumption, curtailing the worldwide pandemic, global warming, and environmental degradation.

4. Pre-Treatment and Processing of Biomass

4.1. Drying of Biomass

The selection of pre-treatment and processing methods may influence the reduction in extraction time, an increase in extraction yield, quality of the biological compounds, and reduction in input energy [28]. The drying of any biomass inhibits microbial growth [18], and it aids in the longer shelf life and transportation costs due to the weight and space of dry products [29–31]. Drying can affect the phytochemical components of the thermally sensitive components [29,32–34], and the process can also contribute to improved conservation of the bioactive compounds against oxidative [35] and enzymatic activities [36] and spoilage bacteria [30,37,38], enabling cellular destruction [28,30,35]. There are many different drying methods, e.g., thermal through natural convection (shade and open sun drying), forced convection (oven drying, solar drying, and heat pump drying), freeze-drying, greenhouse drying, microwave drying, and infrared drying [28]. The freeze-drying method retains the bioactive compounds of the dried product due to minimal thermal damage to the cell tissue, thermolabile compounds, and its porous surface, enabling increased penetration of solvents [30,35,39] Olive leave extracts pre-treated with a hot air drier at 120 ◦C showed higher phenolic recovery compared to freeze-drying (loss of polyphenols reached up to 39% in dry weight). Freeze-drying shows great potential in the extraction of the total phenolic content [35,40]. Ahmad-Qasem [35] reported that temperature plays a key role in the drying process as it may be beneficial or unfavourable to the microstructure of the biomass and the use of hot air drying at a high temperature. The study by Ahmad-Qasem [35] also reported better extraction efficacy of some phenolic compounds in olive leaves when compared to samples dried at lower temperatures and by drying at a moderate to low temperature may need a longer drying time to reach the desired moisture content of the biomass.

4.2. Choice of Solvents

The solvent selection is crucial in determining the bioactive compounds of plants used for extractions. Ideal extraction solvent properties include low toxicity, evaporating easily at low temperatures, having good solubility of the target compound, and being sufficiently volatile. The factors affecting the selection of solvents are the rate of extraction, diversity of compounds extracted, ease of handling of extracts, and the cost-effectiveness of the extraction solvents and targeted compounds. Plants consist of various bioactive compounds

with varying polarities. Various techniques have been developed and used to obtain pure compounds determining the structure and biological activity [41]. Many solvent extractions have been done to obtain phytochemical compounds for their activity against pathogens. Different phytochemicals have different structural features and consist of different phytochemical compounds as well as action mechanisms as described below:

• Phenols and polyphenols are obtained from acetone and ethanol solvent extractions which consist of C3 sidechain, hydroxyl groups and a phenol ring e.g., catechol, epicatechin, cinnamic acid that has antimicrobial, anthelmintic, and antidiarrheal activity. The mechanism of action of polyphenols binds to proteins (adhesins), inhibits enzymesubstrate deprivation, complexes with the cell wall, makes intestinal mucosa more resistant and reduces secretion, increases the supply of digestible proteins by animals by forming protein complexes in the rumen, and causes a decrease in gastrointestinaltract metabolism [42,43].

• Chloroform, methanol, and ethanol solvents extract mainly quinones. They consist of aromatic rings, two ketone substitutions e.g., hypericin that has antimicrobial activity. The mechanisms of action of quinones inactivate enzymes, complex with the cell wall, and bind to proteins (adhesins) [42,43].

• Ethanol and water mainly extract tannins which consist of polymeric phenols e.g., ellagitannin which has antimicrobial anthelmintic and antidiarrheal activities. The mechanism of action of tannins allows the binding of proteins (adhesins), inhibits enzyme-substrate deprivation, complexes with the cell wall, makes intestinal mucosa more resistant and reduces secretion, increases the supply of digestible proteins by animals by forming protein complexes in the rumen, and causes a decrease in gastrointestinal-tract metabolism [42,43].

• Chloroform solvents extract mainly flavonoids which consist of phenolic structure, a carbonyl group, hydroxylated phenols C3 –C5 unit linked to an aromatic ring, flavones and a +3-hydroxyl group that has antimicrobial, anthelmintic and antidiarrheal activity. The mechanism of action of flavonoids is complex with the cell wall, binds to proteins (adhesins), inhibits the secretion of autocoids and prostaglandins and inhibits contractions caused by spasms [42,43].

• Ether solvent extracts mainly coumarins and it consists of phenols made up of fused benzenes e.g., warfarin with antimicrobial activity. The mechanism of action of coumarins allows the interaction with eukaryotic DNA [42,43].

• Water, ethanol, chloroform, and ether solvents extract mainly terpenoids which consist of fatty acids and acetate units with antimicrobial activity. The mechanism of action of terpenoids inhibits the release of autocoids and prostaglandins [42,43].

• Lectins and polypeptides can be extracted by water which consists of mainly extracts proteins e.g., mannose-specific agglutinin, and fabatin that has antimicrobial activity. The mechanism of action of lectins and polypeptides blocks viral fusion or adsorption. [42,43].

5. CONCLUSIONS

One of a kind sources of bioactive substances with both biological and therapeutic uses are plants. In order to extract bioactive compounds, the choice of solvents is crucial. Over time, antimicrobial compounds and textile treatments have become more popular. Although synthetic antimicrobial drugs are very efficient against bacteria, they are harmful to both human health and the environment. To increase the duration of the antibacterial power and resistance to washing on textile substrates, further research on plant-based antimicrobial agents and finishing is needed. The emergence of "super germs" has led to an international health concern because of antibiotic resistance. In order to develop alternative medications, more study must be done on medicinal plants. Untapped medicinal plants should be investigated for their bioactive qualities and solvents that are usually thought to be safe. The most cost-effective extraction, drying, and pre-

treatment techniques should be thoroughly investigated for upcoming treatments.

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