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A Comprehensive Review on Assessment of Antioxidant and Antimicrobial Activity of Various Medicinal Plants

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ABSTRACT:
Numerous studies have suggested that around two-thirds of all species of medicinal plants have strong antioxidant capacity. Antioxidants are particularly helpful because they reduce oxidative stress (OS) in cells and so aid in the prevention and treatment of many diseases, including cancer, cardiovascular disease, and a variety of inflammatory conditions. The antioxidant capacity of several medicinal plant components, including leaves, stems, roots, seeds, fruits, and bark, is covered in this article. Because they serve as food preservatives, synthetic antioxidants butylated hydroxy-anisole (BHA) and butylated hydroxytoluene (BHT) are widely used in foods. Several naturally occurring antioxidants are more effective than manufactured antioxidants.Employing a microbroth dilution experiment, the antibacterial potential of 77 extracts from 24 plants was examined against 8 bacteria and 4 harmful fungi. Minimum inhibitory concentration (MIC) is the lowest concentration of the extract that prevents any visible microbiological growth following treatment with p-iodonitrotetrazolium violet.
Keywords: Antioxidant, antimicrobial activity, BHA, BHT.

I. INTRODUCTION:

Even at extremely low doses, antioxidants suppress redox processes.[1]Free radicals may harm cells because they are extremely reactive, and unstable reactive oxygen/nitrogen species (ROS/RNS) such the superoxide anion radical, hydrogen peroxide, hydroxyl radical, and singlet oxygen [2] can trigger a cascade of events.[3] RNS and ROS are often produced by the aerobic system as byproducts. Some of the physiological functions of ROS in cells include cellular signalling and pathogen defence.[4] However, excessive ROS can eventually result in DNA, lipid, and protein damage, which can lead to tissue damage and cell death.[1] An imbalance between oxidants and antioxidants causes oxidative stress (OS). A range of illnesses, including cancer, neurological disorders, metabolic syndrome, cardiovascular, and inflammatory diseases, have been demonstrated to be strongly impacted by OS, according to recent studies. The OS balance in the body may be impacted by a variety of factors, including dietary, environmental, genetic, radiation, and toxic exposure factors. Food-derived oxidants and antioxidants can change the body's OS homeostasis.[5] Different foods disrupt complex antioxidant systems, impairing their ability to fight free radicals and avert cell harm.[3]

Types of antioxidants:
Enzymatic and non-enzymatic antioxidants are the two kinds of antioxidants that play a part in preventing oxidative stress.[7]

1. Non-enzymatic/dietary antioxidants
Ascorbic acid (vitamin C), -tocopherol (vitamin E), omega 3 fatty acids, -carotenes or carotenoids (vitamin A and lycopene), various types of polyphenols and flavonoids (such as anthocyanin, a type of flavonoid), and coenzyme Q10, a type of protein, are examples of non-enzymatic antioxidants. An essential water-soluble extracellular antioxidant with the power to counteract ROS in vulnerable cells is vitamin C. A fat-soluble antioxidant called vitamin E acts in cell membranes to stop the lipid peroxidation of fatty acids. Similar to this, -carotene and other carotenoids are crucial for avoiding the oxidation of lipid-rich tissues.[8]

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2. Enzymatic antioxidants

Enzymatic antioxidants are a class of endogenous antioxidants that act as defences against radical cell damage in addition to diet. These include glutathione reductase (GR), glutathione peroxidase (GSH-Px), catalase, superoxide dismutase (SOD), and catalase. They play significant parts in the metabolism of hazardous oxidative metabolites.[9] The amino acids glycine, glutamate, and cysteine are combined to create the water-soluble antioxidant GSH-Px. Scavenging ROS and xenobiotic compounds metabolism is directly impacted by GSH-Px.[10] Free iron and copper ions that can catalyse oxidation processes can be scavenged by metal binding proteins. These include ceruloplasmin, albumin, ferritin, lactoferrin.[11]

Medicinal plants having anti-oxidant properties:

1. **Gingko biloba:**Ginkgo biloba leaf extract has antioxidant characteristics that are beneficial in the treatment of chronic disorders like cancer, neurological diseases, and cardiovascular diseases. Its method of action directly contributes to the reduction of free radicals and indirectly contributes to the prevention of their generation. Hydrogen peroxide (H2O2), ROS/RNS, and ferryl ion species can all be scavenged by it.[12] Because it boosts the activity of other enzyme antioxidants as catalase, SOD, GSH-Px, and heme oxygenase, the G. biloba leaf extract indirectly functions as an antioxidant.[13]The active components of G. biloba are quercetin, kaempferol, and bilobalides (terpenoids), which exhibit their antioxidant properties in various ways. For example, flavonoids inhibit prostaglandin synthesis by inhibiting the activity of cyclooxygenase-2, which results in a decrease in colon cancer metastasis. Bilobalides were also discovered to increase the activities of the enzymes SOD and catalase.[14,15]

2. **Glycyrrhiza glabra:**Liquorice's primary chemical, glycyrrhizin[16], has antioxidant effects by preventing neutrophils from producing free radicals at the site of inflammation.[17] Aside from antioxidant potential, it also possesses anti-hyperglycemic, anti-fungal, antibacterial, anti-allergic, anti-malarial, immunomodulatory, expectorant, antispasmodic, antiviral, anti-ulcer, and tyrosinase enzyme inhibitory potential.

3. **Trachyspermumammi:**The common name for Trachyspermumammi is ajwain. The antioxidant properties of ajwain are caused by the presence of flavones. In an animal model research where toxicity was caused by hexachlorocyclohexane, ajwain demonstrated antioxidant properties. T. ammi also has hepatoprotective, anti-ulcer, antiviral, spermicidal, analgesic, antinociceptive, antibacterial, antifungal, insecticidal, antiplatelet, anti-inflammatory, diuretic, anti-lithiasis, antiviral, and detoxifying activities. According to an animal model study[18], it can be teratogenic and may be harmful to take when pregnant.

4. **Aloe barbadensis:**The popular name for A. barbadensis is aloe vera, and this plant's gel includes antioxidant enzymes including SOD, GSH-Px, and phenolic chemicals that are what give it its anti-oxidant benefits. Additionally, it improves blood quality by enabling more efficient nutrition and oxygen delivery to cells. A. barbadensis also has qualities that help heal wounds, moisturise, fight ageing, boost the immune system, and are anti-inflammatory, antidiabetic, anti-mutagenic, antibacterial, antifungal, and antiviral. [19]

5. **Embelica officinalis:**Embelica officinalis has properties that are anti-diabetic, anti-diarrheal, anti-inflammatory, hypocholesterolemic, hepatoprotective, anti-tussive, anti-cancer, cardioprotective, and antiproliferative. The primary chemical components of E. officinalis that are active against various free radicals, including superoxide, nitric oxide, and iron reduction, include ascorbic acid, tannins, and polyphenolic compounds. E. officinalis active ingredients work well as metal ion chelators because they can stop oxidative cascades. [20]

6. **Andrographis paniculate**: Antioxidant, anti-inflammatory, anti-hyperglycemic, anti-hypoglycemic, antiseptic, and cardioprotective activities are all present in Andrographis paniculate. Under its influence, catalase, SOD, and GSH-Px s-transferase enzyme activities were increased, whereas lactate dehydrogenase activity was decreased. [21] Another investigation revealed that cellular activity was inhibited by ROS production. [22]

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7. **Withania somnifera:**The anti-inflammatory, sedative, aphrodisiac, alternative, and antioxidant properties of Withania somnifera are widely documented. Polyarthritis, lumbago, asthma, leucoderma, scabies, ulcer, and leucorrhea are among the conditions for which it is advised. Equimolar doses of withaferin, sitoindoside VII-X, and other active components of W. somnifera boosted the activity of catalase, SOD, and GSH-Px enzymes in rat brain. [23,24]

8. **Terminalia belerica:**Extracts of the Terminalia belerica plant shown antibacterial, ulcer-preventing, immunomodulatory, wound-healing, and antioxidant properties. It has antioxidants that are both enzymatic and non-enzymatic and scavenge hydroxyl free radicals, which are known to cause cellular damage. [25]

9. **Salvia haematodes:**Alkaloids, saponins, glycosides, and anthraquinones are not found in S. haematodes, and the primary chemical components that are present are flavonoids, steroids, and terpenoids. The ability of plants to scavenge free radicals using 1,1-Diphenyl-1-picrylhydrazyl (DPPH) is frequently employed to assess their antioxidant capacity. Discoloration of the DPPH's violet hue indicated that the antioxidant compounds in S. haematodes were scavenging free radicals. In addition to its antioxidant potential, it has analgesic, antimicrobial, antihypertensive, antispasmodic, and antidiarrheal activities. The literature claims that flavonoids are what cause the antioxidant action. [26,27]

Antimicrobial activity:

The study of medicinal plants has garnered a lot of attention in recent years on a global scale. [28,29] The use of medicinal plants in different conventional, complementary, and alternative methods of treating human ailments has been supported by a growing amount of data. Numerous secondary metabolites present in plants, including tannins, terpenoids, alkaloids, flavonoids, and others, have been discovered in vitro to exhibit antibacterial effects. [38,39]

Clinical microbiologists are interested in the subject of antibacterial plant extracts for two reasons. Since some of these phytochemicals are currently being tested on people, it is extremely conceivable that they will end up in the arsenal of antimicrobial medications that doctors prescribe. Since every antibiotic has a finite shelf life, researchers are also looking for other sources, particularly plant sources. Second, more people are becoming aware of the issues related to the overprescribing and abuse of conventional antibiotics. Additionally, a lot of individuals want more control over their medical treatment. Self-medication using a variety of plant components is, to some extent, a popular practise and is easily accessible over the counter at national food shops and herbal suppliers. These compounds are frequently of questionable quality. While part B primarily focuses on the numerous categories of phytochemicals demonstrating therapeutic qualities, section A highlights the many medicinal plants that have demonstrated antibacterial, antifungal, antiviral, and antiprotozoal capabilities.

Antibacterial Activity:

According to a study done by Chakraborty and colleagues, the acarbazole alkaloid "clausenol" that was isolated from an alcoholic extract of clausennanisata's stem bark shows antibacterial and antifungal action. [40] With regard to Staphylococcus aureus, coagulase-positive Staplylococcus aureus, Bacillus subtilis, Bacillus stearothermophillus, Escherichia coli, Salmonella typhi, and Salmonella dysentriae, the acetone and alcoholic extracts of Cassia alata leaves shown substantial invitro antibacterial activity. Additionally, acetone extract prevented the development of Vibrio cholerae whereas alcoholic extracts hindered the growth of Klebsiella pneumoniae. [41]In vitro bactericidal activity against 3 grammes of negative pathogens (Escherichia coli, Salmonella typhi, and Proteus vulgaris) and 2 grammes of positive strains (Staphylococcus aureus and Corynebacterium diphtheriae) was demonstrated by the alcohol extract of dry nuts of Semecarpus anacardium (Bhallatak). The alcoholic extracts of several plant components, including the leaves, twigs, and green fruits, have also been proven to exhibit antibacterial effects in later investigations, particularly the leaf extract. [42] The hexane extract of the stem bark of Amona glabra, Thymus vulgaris, Cinnamonumzeylanium, and Cuminum cyminum showed significant antibacterial, antifungal, and mild insecticidal, sporicidal, and cytotoxic properties. Standard gramme positive and gramme negative bacteria were cultivated on agar slants, and the volatile components of the hexane extracts of these plants were tested against them. The

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findings were expressed as a percentage inhibition of the area of the slants. Thymus vulgaris, one of the four plants chosen, had the strongest antibacterial activity. [43]

Antifungal:

When tested against strains of Candida albicans, four siddha medicines—Nandhi mezhugh, Parangipattaichoornam, Erasakenthi, mezhugu, and Vaan mezhugu—were found to have considerable antifungal activity. [44] When evaluated in vitro using the agar dilution method on 88 clinical isolates of dermatophytes, the aqueous and ethanolic extracts of Azadirachta indica leaves were found to have anti-dermatophytic action. Compared to the aqueous extract, the action was more pronounced in the ethanolic extract. [45] In 14 medicinal herbs, Rai found antimycotic efficacy against the test pathogen Pestalotiopsismangiferae. Catharanthus roseus (88%) and Eucalyptus globulus (88%) demonstrated the highest anti-mycotic activity.[46]

Both in vitro (against 13 strains of Candida albicans) and in vivo (experimentally produced vaginal and systemic candidiasis in mice), essential oil extracted from the plant Santolina chamaecyparissus shown strong antifungal activity. [47] Additionally, the hair root invasion test revealed action against experimentally produced superficial cutaneous mycosis in guinea pigs. [48] When examined using the spore germination assay, the essential oil extracted from the leaves of Aegle marmelos showed considerable antifungal activity against several fungal isolates and 100% suppression of all the tested fungi's spore germination. Kinetic analyses revealed that the inhibition was time- and concentration-dependent. [49]Aspergillus niger, R. japonicum, Candida albicans, C. tropiathis, and R. glutinis were among the fungi that were significantly inhibited by the petroleum ether, chloroform, acetone, and ethanol (95%) extracts of Cassia alata leaves.14 The three phytopathogenic fungus, Fusaiumvasinfectum, Alternaria tenuis, and Dreschleraoryzae, were effectively inhibited by the natural xanthones isolated from the fruit hulls of Garcinia mangostana. [50] It was discovered that the root of Withania somnifera was successful in extending the lives of Bulb/C mice given an intravenous infection with Aspargillus fumigatus. Withania somnifera therapy was found to improve phagocytosis and the ability of peritoneal macrophages to destroy inside of cells, which suggests that the plant may have the ability to stimulate macrophage function in infectious situations. [51]

Antiviral:

An extract made from the fruit rind of Terminalia belerica was used to isolate termilignan, thannilignan, 7-hydroxy-3, 4-(Methylenedioxy) flavone, and anolignan B. All of them shown in vitro anti-HIV-1, anti-malarial, and anti-fungal action. [52] The Alexander cellline, obtained from human hepatocellular carcinoma, was treated with the aqueous extract of Phyllanthusamarus in an in vitro investigation. The Alexander cellline has the ability to secrete the Hepatitis B surface antigen (HbsAg) in the supernatant. The findings proved that Phyllanthus amarus has anti-hepatitis virus properties at the cellular level by successfully reducing the release of HbsAg for 48 hours. [53] RNA viruses including the Chandripura virus, measles virus, polio vaccine viruses type 1, 2, and 3, and polio wild type viruses type 1, 2, and 3 as well as DNA viruses like the herpes type 1 and 2 viruses were studied in vitro using the triterpenoid glycoside glycyrrhizin from Glycyrrhiza glabra. While the RNA viruses were suppressed at greater doses (1.216mM), the DNA viruses' ability to generate plaque was decreased at lower values (0.608mM). [54] Mangrove plant extracts were screened in vitro for anti-immunodeficiency virus activities by Premanathan et al. The extract was cultured with HIV-infected MT-4 cells, and antiviral activity was found using a tetrazolium-based colorimetric test. Seven extracts were shown to be efficient, five of which (Exoecariaagallocha, Ceriopsdecandra, Rhizophora apiculata, and Rhizophoralamarckii leaves and the bark of Rhizophora mucronata) totally inhibited the virus's adsorption to the cells.anti-malarial and anti-protozoal Anopheles stevensi and Aedes aegypti reproduction was stopped in 45 days by using wood scraps formed into balls and soaking in 5% Neem oil (Azadirachta indica) diluted in acetone. [55]A similar application of Azadirachta indica cream at a rate of 2.0 gm/person on exposed body areas dramatically reduced the risk of getting bitten by Aedes, Culex, and Anopheles mosquitoes.The anti-malarial efficacy of 22 ethanolic and petroleum extracts of Artemisia Japonica, Artemisia maritima, and Artemisia nilegarica was examined both in vivo and in vitro. All the substances increased the life time of the mice in in vivo experiments utilising Balb/c mice and the Rane test. In vitro, all three substances prevented schizont formation in

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plasmodium falciparum strains that were susceptible to chloroquine. [56]

Antimalarial:

Anopheles stephensi and Aedes aegypti reproducing was stopped in 45 days by using ball-shaped wood scrapings soaked in 5% Neem oil (Azadirachta indica) diluted in acetone and placed in water storage over headtanks. [57] A similar application of Azadirachta indica cream at a rate of 2.0 gm/person on exposed body areas dramatically reduced the risk of getting bitten by Aedes, Culex, and Anopheles mosquitoes. [58] The anti-malarial activity of Artemisia Japonica, Artemisia maritimia, and Artemisia Nilegarica ethanolic and petroleum extracts was examined in vivo and in vitro. The Rane test was used in invivo research with Balb/c mice, and all the drugs increased the animal's lifespan. In vitro, all three substances prevented schizont formation in plasmodium falciparum strains that were susceptible to chloroquine. [59]

Antileishmanial:

The topoisomerase I enzyme from Leishmania donovani was reported to be catalytically inhibited by the methanolic extract of Swertia charata. The extract, when subjected to fraction-action, produced the secoiridoidsAmarogentin, Amaroswerin, and Sweroside. Amarogentin was discovered to be a strong inhibitor of topoisomerase 1 and worked by binding with the enzyme to stop the formation of binary complexes. [60] Growing interest exists in linking a plant's phytochemicals to its medicinal effects.

Antitrypanosomally:

Partheniumhysteroporus flower crude 50% ethanolic extract showed trypanocidal efficacy against Trypanosoma evansi both in vitro and in vivo. [61] Growing interest exists in linking a plant's phytochemicals to its medicinal efficacy. [62] The primary classes of antibacterial compounds from diverse plants are described in the next section.

II. CONCLUSION:

Flavonoids and phenols, which are responsible for antioxidant action, are abundant in medicinal plants. Due to their part in the body's defensive systems against different free radicals, antioxidants are crucial. Increasing antioxidant consumption through conventional cuisine and herbal supplements may assist to maintain healthy levels and lower the chance of developing various ailments. Herbalists are not the only ones that study or analyse medicinal plants; chemists are also keen to find novel chemical components that have few negative side effects and will expand the field of phytochemistry. Plant extract was rated as having excellent antimicrobial activity if its MIC was less than 100.0 g/ml, moderate antimicrobial activity between 100.0 and 500.0 g/ml, and low antimicrobial activity exceeding 500.0 g/ml.

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