

REVIEW ON PHYTOCHEMICAL COMPOSITION AND PHARMACOLOGICAL ACTIVITIES OF SOME SELECTED GYMNOSPERMS

¹Kiran, ²Chanchal Malhotra

¹M.Sc. Student, Department of Botany, Baba Mastnath University, Asthalbohar, Rohtak

²Assistant Professor, Department of Botany, Baba Mastnath University, Asthalbohar, Rohtak

E-mail: Chanchalmalhotra2007@rediffmail.com

KEY WORDS

Phytochemicals,
Platycladus
orientalis, *Araucaria*
heterophylla, *Cycas*
revoluta

ABSTRACT

Plant-derived substances have recently attracted a lot of attention due to their wide range of applications. Plants are the most abundant bio-resource in traditional medicine, food supplements, folk medicine, pharmaceutical intermediates, and chemical entities for synthetic drug development. At the moment, naturally occurring phytochemicals are a hot topic in science. Technically, the term "phytochemical" refers to all naturally occurring chemical compounds found in plants, with a focus on physiologically active phytochemicals. Fundamental phytochemical investigations should be encouraged, especially in view of the urgent need to discover new bioactive molecules with greater efficacy and less side effects than existing drugs. Gymnosperms, a group of Spermatophytes are evergreen trees with soft woods and characterized by the presence of cones with naked seeds, whose evolutionary history dates back 300 million years are well-known for their therapeutic significance in a variety of medical systems, including contemporary medicine, folk medicine, and traditional medicine. Gymnosperm plants are now mostly planted in gardens. Apart from decoration, gymnosperm plants were also utilized in medicine. So this review sheds a light on the medicinal potentiality of *Platycladus orientalis*, *Araucaria heterophylla*, *Cycas revoluta*, *Thuja occidentalis* and *juniperus virginiana*.

1. INTRODUCTION

Since time immemorial, nature has provided therapeutic agents, and drug-producing plants in the wild constitute a key requirement of indigenous systems of medicine with deep roots in our cultural heritage. Gymnosperms in India are divided into 14 genera and 75 species. *Cycas*, *Cedrus*, *Abies*, and *Taxus* are referenced in Siddha literatures, whereas *Pinus* and *Ephedra* are listed in Ayurvedic and Unani literatures in Indian Traditional medicinal system (Radha *et al.*, 2018). While the modern medical system has progressed, diseases caused by germs (bacteria, fungus, viruses, etc.) and stress-related diseases remain important concerns. The human body's metabolic oxidative stress and microorganisms' medication resistance to various therapies are both on the rise (Levy, 2002). The indiscriminate use of

antibiotics for the treatment of diseases has resulted in the development of multiple drug resistance in bacteria (Usha and Jyothsna, 2010). Antibiotic resistance develops in a variety of bacteria for a variety of reasons, including the pathogen's unique interaction to antibiotics, antimicrobial agent usage, host features, and environmental factors. To combat microorganism antibiotic resistance, researchers are extracting novel chemicals from natural sources and developing new antibiotics that are not dependent on currently available synthetic antimicrobial medicines (Chanda *et al.*, 2011).

2. Phytochemicals (Secondary metabolites)

In the field of medicine, natural substances, often known as phytochemicals, play an essential role. The type of chemical compound that plants create and store determines their medicinal and pharmacological qualities. These secondary metabolites are the chemical constituents of medicinal relevance, and examining the chemical constituents of a plant can only disclose those compounds that have collected to some level at a certain organ of a given plant. The presence or absence of such chemicals is mostly determined by the amount of plant material used, as well as the analytical method used (Harborne, 1973). The type of chemical compound that plants create and store determines their medicinal and pharmacological qualities. They are frequently employed in human medicine, veterinary medicine, agriculture, scientific research, and a variety of other fields (Treare and Evans, 1985). Bioactive properties in plants can be found in secondary metabolites (Sindhi *et al.*, 2013; Irchhaiyaet *et al.*, 2015), which have a smaller molecular structure than primary molecules (Angajiet *et al.*, 2012). There are about a thousand of recognized phytochemicals and many more are still undiscovered. While phytochemicals are classed based on their biological functions, a single molecule can serve as both an antioxidant and an antibacterial agent. Because of the great range of phytochemicals, precise classification has been unable to achieve so far. According to their involvement in plant metabolism, phytochemicals are now classed as primary or secondary constituents. Sugars, amino acids, proteins, nucleic acid purines and pyrimidines, chlorophyll, and other primary ingredients are among them. The remaining plant compounds, such as alkaloids, terpenes, flavonoids, lignans, plant steroids, curcumin, saponins, phenolics, flavonoids, and glucosides, are secondary constituents (Hahn, 1998).

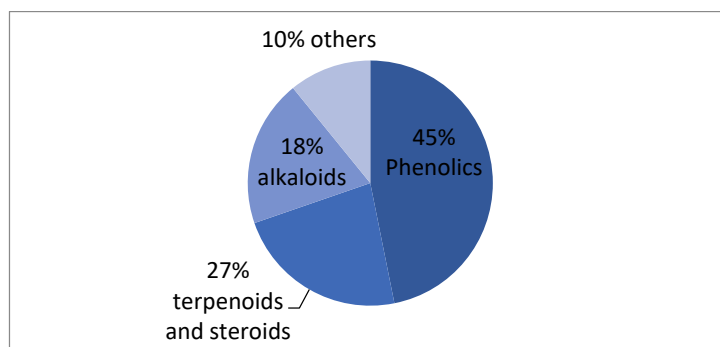


Fig.1. Pie chart representing the major groups of phytochemicals

3. Pharmacological Activities of Secondary Metabolites

There are different metabolic processes used by plants to produce secondary metabolite ensures the presence of particular structures in these defense molecules that can be used to build new medications and therapeutic products. As a result, plants are a precious source of compounds that can be utilized to improve health and treat ailments. Antitumor, antioxidant, and antibacterial activities are among the plants' positive pharmacological activities. Flavonoids produced in response to microbial infection have been discovered to have antibacterial properties in vitro against a wide range of pathogens. Their capacity to interact with extracellular and soluble proteins, as well as the bacterial cell wall, accounts for their activity (Marjorie, 1996). Flavonoids primarily function as buffers, capturing free radicals to produce the flavinic radical, which is significantly less reactive due to the delocalization of missing electrons in its structure. Flavonols like quercetin can also chelate transition metal ions like iron or copper, preventing reactive oxygen species from forming (Wang *et al.*, 2018). Saponins are known for their ability to produce foams in aqueous solutions, as well as their hemolytic activity, cholesterol binding capabilities, and bitterness (Sodipo *et al.*, 2000, Okwu, 2004). Tannins attach to proline-rich proteins, preventing them from being synthesized. Natural diterpenes have a variety of biological effects, including anti-inflammatory, antibacterial, and antispasmodic properties (Tirapelliet *al.*, 2008). In plants, phenolic compounds have a variety of functions: they oxidize fast and act as antioxidants (Martins *et al.*, 2016). Polyphenols have been found to attach to DNA chains in bacteria, inhibiting protein production. Terpenes have a variety of biological roles and are involved in both primary and secondary metabolism in plants. They act as defensive chemicals, poisonous substances, and insect food deterrents in secondary metabolism and responsible for attracting pollinators in some plants (Veitch *et al.*, 2008). Antimicrobial resistance is serious health issue that has been brought to the attention of medicinal plants. Infections caused by resistant bacteria are thought to kill roughly 25 thousand persons every year in the European Union (Fischer and Bild, 2019). These figures show that finding novel antibacterial compounds is a top priority in basic research as well as a necessity for the pharmaceutical sector.

The potentiality i.e. phytochemical composition, pharmacological activity and uses of five gymnosperms, *Platycladus orientalis*, *Araucaria heterophylla*, *Cycas revoluta*, *Thuja occidentalis* and *juniperus virginiana*, that are commonly used as ornamental plants has been comprehended in this document.

Table 1. Family, common name and native place of reviewed plants are listed in the table below:

S.N.	Name	Family	Common name	Native place
1.	<i>Platycladus orientalis</i> L.	Cupressaceae	Morpankhi, Chinese Arborviate	Asia
2.	<i>Thuja occidentalis</i> Linn.	Cupressaceae	American arborviate, eastern white-cedar	Eastern North America

3.	<i>Cycas revoluta</i> Thunb.	Cycadaceae	Sago palm	China and Japan
4.	<i>Araucaria heterophylla</i> (Salisb.) Franco	Araucariaceae	Australian pine, Triangle tree	Norfolk Island, Australia
5.	<i>Juniperus virginiana</i> L.	Cupressaceae	Eastern red-cedar	Eastern North America

4. Uses and Phytochemical Composition of these Plants:

4.1. *Platycladus orientalis*

Uses: *Platycladus orientalis* was an old therapy for delayed menstruation, and because it stimulates smooth muscles like those in the uterus and bronchial passageways, it's also used to treat bronchitis (Mabey *et al.*, 1998) and as a cough suppressant in traditional Chinese medicine (Takoa *et al.*, 1995). It's used externally to treat infectious skin illnesses like impetigo and scabies (Buben *et al.*, 1992). Fresh leaves of *Platycladus orientalis* have been used to treat bleeding arthralgia (Panhong *et al.*, 1986) and in Chinese medicine to treat gout, rheumatism, diarrhoea, and chronic tracheitis (Kosuge *et al.*, 1981). Hemorrhages, coughs, excessive menstruation, bronchitis, asthma, skin infections, mumps, bacterial dysentery, arthritic aches, and premature blandness are all treated with *T. orientalis* extracts (Brown, 1995).

Phytoconstituents: The fresh plant contains essential oil, reducing sugar, water-soluble polysaccharides, water-soluble minerals, free acid, tannic agents (Harnischfeger and Stolze, 1983), flavonoids, saponins, glycosides, and alkaloids (Jasuja *et al.*, 2013), according to biochemical investigations. The primary monoterpenes in the essential oil of fresh leaves (related to the monoterpene fraction) are 65 percent thujone, 8 percent isothujone, 8 percent fenchone, 5 percent sabinene, and 2 percent -pinene (Harnischfeger and Stolze, 1983; Magda *et al.*, 2004). Carvotanacetone, origanone, myrcene, and camphene are some of the other monoterpenes that have been described (Harnischfeger and Stolze, 1983; Witte, 1983; Berlin *et al.*, 1984; Kawai *et al.*, 1994).

4.2. *Thuja occidentalis* L.

Uses: *T. occidentalis* has been employed in the treatment of liver disorders, psoriasis, enuresis, amenorrhea, cystitis, uterine carcinomas, diarrhoea, and rheumatism in traditional medicine (Akkol *et al.*, 2015; Brijesh *et al.*, 2012). Fungal infections, cancer, and intestinal worms have all been treated using essential leaf oil (Biswas *et al.*, 2011). *T. occidentalis* essential oil has been utilised in folk medicine since ancient times. Hepatoprotection, bronchial catarrh, rheumatism, psoriasis, and even uterine carcinomas were all treated with *T. occidentalis* containing thujone. In cases of snake bite, smallpox, and vaccination-induced toxicity, as well as the proliferation or pathological vegetation, homeopathy uses *Thuja* as one of the principal therapies (Nash, 2002). The tea made from the inner

bark of unwoody twigs have been shown to help with constipation and headaches (Ellingwood, 1919). It's also been used to treat polyps, birthmarks, and wounds (Nemeth and Nguyen, 2020).

Phytoconstituents: The methanolic extract of *T. occidentalis* leaves were found to contain 135.32 mg/g total polyphenols (in gallic acid equivalent) and 3.46 mg/g total flavonoids (in quercetin equivalent) (Nazir *et al.*, 2016). In a recent work, identification of 21.13 g/mL thujone, 2.16 mg/mL total phenolic acids expressed in caffeic acid, and 0.36 mg/mL total flavonoids expressed in rutoside in an ethanolic extract produced from fresh leaves (Stan *et al.*, 2019).

4.3. *Cycas revoluta* Thunb.

Uses: Cycad leaves are eaten as a vegetable in the Philippines and Indonesia, as are the root nodules of *C. revoluta*, which are edible and have been described as a "potato-like" material. The impoverished and people living in hilly areas in famine consume the starch grains derived from the pith and cortical cells of the stem (Zarchini *et al.*, 2011). *Cycas revoluta* has been used as a traditional medicine to treat cough, blood pressure, snake bite, dressing wounds, swollen glands, and stomach purifying. Negmetal *et al.* (2016) utilised the leaves of *Cycas revoluta* to treat blood vomiting and flatulence, skin disorders (Nair and Staden, 2012), while powdered seeds are used to treat hypertension, blood pressure, rheumatism, headache, bone pain, congestion, and other conditions (Khan *et al.*, 2013).

Phytoconstituents: To date, eighty-eight secondary metabolites from nineteen *Cycas* species have been isolated and identified, including flavonoids, terpenoids, lignans, aromatic acids, and sterol. The chloroformic and hydro-alcoholic extracts of the leaves showed presence of alkaloids, saponin and reducing sugars (Lal *et al.*, 2017). Sixty-eight secondary metabolites chemicals isolated from various parts of cycasplant were discovered through distilled water, ethanol, methanol, chloroform, petroleum ether and diethyl ether. In that 25 flavonoids, 15 non-protein amino acids, 09 glucosides, 08 fatty acid, 01 amino acid, 01 diterpenoid, 03 benzenoids, 02 terpenes, 03 benzenoids, 02 terpenes, 03 benzenoids, 02 terpenes, 03 benzenoids, 01 triterpenoid, 01 sterol, 01 ester, and 01 steroid Isolation has occurred (Prakash *et al.*, 2020).

4.4. *Araucaria heterophylla*

Use: In traditional medicine, the aerial portions of *A. heterophylla* Salisb. Franco (syn. *A. excelsa*) were used to treat toothaches (Aslamet *al.* 2013). According to Abdel-Sattaret *al.* (2009) the chloroform extract of *A. heterophylla* resin is high in labdane diterpenes, which have antiulcer, antioxidant, and anticancer properties against MCF7 and HTC116.

Phytoconstituents: These plants produced a variety of phytochemicals, including flavonoids, sesqui- and di-terpenes, and phenylpropanoids (Abdel-Sattaret *al.* 2009) One of the main elements of *Araucaria* species has been identified as essential oil (EO) (Elkady and Ayoub 2018). Saponins from the *Araucaria*

plant have been widely utilised as detergents, insecticides, and molluscicides, and they also have favourable health effects (Shi *et al.* 2004).

4.5. *Juniperus virginiana* L.

Use: Shelterbelts and windbreaks, wood, ornamentals, cedar oil are obtained from *J. Virginiana* (Haverbeke and Read, 1976). Different portions of *Juniperus spp.* have been employed in embalming, medicine, and cosmetics for a long time throughout the Mediterranean Basin (Tumen *et al.* 2013). Juniper products are used in fragrances, cosmetics (Yesenofski, 1996), the food and beverage industry (Madej *et al.*, 2014). Eastern red cedar is an abundant renewable resource and represents a vast potential source of valuable natural products that may serve as natural biocides (Eller *et al.* 2010).

Phytoconstituents

Juniperus species have a broad metabolic profile (coumarins, flavonoids, lignans, sterols, terpenoids, and so on (Seca and Silva, 2006) which is why different extracts from these products are employed in a variety of industries. The extracted phytochemicals had an abietanediterpene moiety, which inhibited melanin formation and tyrosinase activity effectively. This class of diterpenoid has been shown to be extremely safe for use on the skin (Lin *et al.*, 2009). *Juniperus* species bark contains dimericprocyanidins and flavonoid monomers (Kuo and Yu, 1993).

5. Pharmacological Activity of these Plants

5.1. Antimicrobial activity:

Traditional medicine plants offer a variety of chemicals that can be utilized to treat both chronic and infectious ailments. In locations where the usage of plants is still important, a huge knowledge of how to employ plants against various illnesses is likely to have collected (Fatima *et al.*, 2012). *T. orientalis* has high levels of alpha, beta, and gamma thujaplicin, which act as chelators for *Solmonella typhimurium* in low concentrations (Akers *et al.*, 1980). *T. occidentalis* was also found to be resistant to *Saccharomyces cerevisiae*, *Aspergillusparasiticus*, *Aspergillusniger*, *Aspergillusflavus*, *Trichophytonrubrum*, and *Fusariumsolani* (Gupta and srivastva, 2002). Belliliet *al.* (2018) found that essential oil extracted from *Thujaoccidentalis* leaves and cones had antimicrobial activity against Gram-negative bacteria (*Escherichia coli*, *Salmonella typhimurium*, *Aeromonashydrophila*, and *Pseudomonas aeruginosa*), Gram-positive bacteria (*Staphylococcus aureus*, *Listeria monocytogenes*, and *Bacillus cereus*), fungus (*Aspergillusniger*), and yeast (*Candida albicans*). According to Mourya *et al.*, (2011), the hydroalcoholic extracts of *C. revoluta* leaves had shown substantial antibacterial action against *E.coli*, *Klebsiellapneumoniae*, and *Saccharomyces cerevisiae*, whereas chloroform extract had similar antibacterial activity. Plant pathogenic fungi, Gram-positive and Gram-negative bacteria were all inhibited by novel antimicrobial peptides from *C. revoluta* (IC₅₀ = 7.0-8.9 g/ml) (Yokoyama *et al.*, 2008). *A. heterophylla* extracts showed antimicrobial activity against the four strains *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans*, and *Aspergillusniger*, on cup agar (Hamed, 2018).

J. virginiana Cedarwood oil (CWO) act as a safe natural bioactive agent, prevents wood against microbes (Clark *et al.*, 1990). In a preliminary screening approach, several isolated potent isomeric diterpenoids or abietanediterpene analogues also displayed strong anti-microbial properties against a wide range of human diseases. The antibacterial (against *Staphylococcus* MRSA and *Bacillus* sp.) and antifungal activities against yeast of the isolated compounds composed of highly bioactive diterpenoids as shown (Lin *et al.*, 2009).

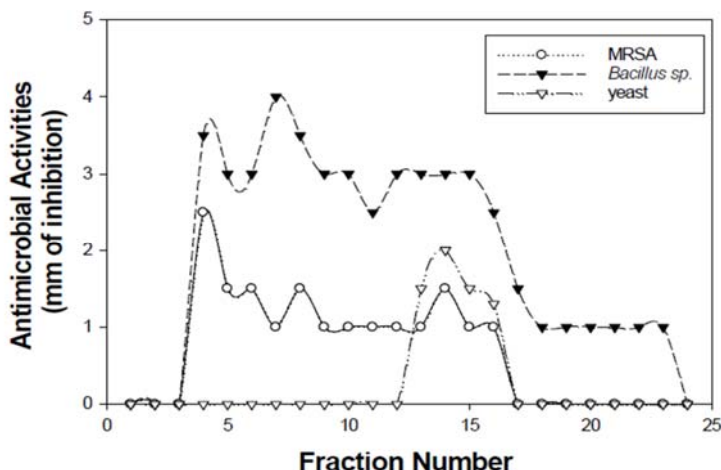


Fig.1.Antimicrobial activities of isolated fractions containing highly bioactive diterpenoids.

https://www.researchgate.net/profile/HugoFassola/publication/257510641_Comparing_silvopastoral_systems_and_prospects_in_eight_regions_of_the_world/links/55ca3aa508aebc967dfbde9e/Comparing-silvopastoral-systems-and-prospects-in-eight-regions-of-the-world.pdf#page=188

Continuous research into new classes of antimicrobials is required in light of the continuously rising microbe resistance to current medications, which is a severe challenge in antimicrobial therapy (Essawi and Srour, 2000).

5.2. Antiinflammatory activity:

Panhong *et al.* (1986) investigated the anti-inflammatory properties of fresh *P. orientalis* leaves. The anti-inflammatory of aqueous methanolic extract of *T. orientalis* fruit (To-Cr) in albino rats were evaluated using a carrageenan-induced inflammatory model, an acetic acid-induced writhing test, and hot plate procedures (Tanveer *et al.* 2015). In human umbilical vein endothelial cells, Moon *et al.* (2008) studied the anti-vascular inflammatory activity of an aqueous extract of *T. orientalis* (ATO) and its probable mechanisms (HUVECs). The adhesion of tumour necrosis factor and U937 monocytes to HUVECs was decreased by aqueous extract re-incubation, suggesting that it may limit monocyte binding to endothelium.

Silva *et al.* (2017) found that the aqueous extract and polysaccharide fraction derived from *T. occidentalis* had anti-inflammatory effect in experimental models of acute inflammation.

The essential oil of *A. heterophylla* (particularly at a low dose of 100 mg/kg) and its nanoemulsion (especially at a high dose of 200 mg/kg) showed a significant reduction in TNF- and IL1 levels, as well as a noteworthy improvement in the inflammatory cytokine (IL-6). Germacrene-D, one of the reported sesquiterpenes, had a high concentration (10.25 percent) and was predicted to play an important role as an antiinflammatory agent (Elshamy *et al.*, 2020).

5.3. Antioxidant activity:

Nizam and Mushfiq (2007) investigated the antioxidant properties of water and ethanolic extracts of dried and powdered *T. orientalis* leaves. Water and alcohol extracts of *T. orientalis* reduced DNA hydrolysis by 72.859 percent and 65.312 percent, respectively, at a dosage of 200 mg. 2,2'-Azobis(2-amidinopropane) dihydrochloride produced RBC hemolysis was likewise reduced by water and alcohol extracts of *T. orientalis* to the amount of 69.30 percent and 54.55 percent, respectively. The antioxidant activity of the ethanolic fraction (EFTO) of *T. occidentalis* in rats was noted by Dubey and Barta, (2009). At dosages of 100, 150, 200, 250, and 300 g EFTO, EFTO prevented lipid peroxidation produced by FeSO₄. The antioxidant capability of the *Thuja occidentals* methanolic extract was attributed by Nazir *et al.* (2016) to strong DPPH radical scavenging activities, ABTS, NO, and lipid peroxidation assays. Superoxide anion radical scavenging activity in *C. revoluta* leaves was measured. In comparison to chloroform extract, the hydroalcoholic extract had much higher anti-oxidant activity (Mourya *et al.*, 2011). The anti-oxidant capability of *C. revoluta* leaf extracts in methanol, ethanol, and ethyl acetate was determined using the DPPH assay. All extracts had strong anti-oxidant properties, with the methanolic extract having the highest activity (110.25 g/ml). When examined using the DPPH method, neohesperdine, amentoflavone, and amentoflavone- 4-O—D- glucopyranoside from *C. revoluta* had anti-oxidant activity approximately two to four times that of quercetin at a concentration of 12.5 g/mL (Zaffar *et al.*, 2014). In evaluation of the Total antioxidant capacity (TAC) of different solvent extracts of *A. heterophylla*, the phosphomolybdenum antioxidant assay was used. The most active n-BuOH extract had a (TAC) value of 506.66 mg AAE /g dry extract, followed by 85 percent methanol, EtOAc, petroleum ether, and dichloromethane extracts with 448.20, 370.25, 397.94, and 248.20 mg AAE /g dry extract, respectively (Hamed, 2018). *Juniperus* species bark contains dimericprocyanidins and flavonoid monomers, both of which have significant antioxidant effects (Kuo and Yu, 1993).

5.4. Anticancer activity:

C. revoluta leaves have been used in traditional medicine to treat a variety of cancers (Khan *et al.*, 2013) and seeds have been used to treat certain types of tumor (Kowalska *et al.*, 1995) and treatment for colon cancer (Mandalet *et al.*, 2012). Jafarian *et al.* (2004) conducted cytotoxicologic experiments on cancer cells using extracts of Iranian *Juniperussabina* and *P. orientalis*. The extracts were tested for cytotoxicity against three human tumour cell lines (Hela, KB, and MDA-MB-468). A MTT-based

cytotoxicity test was used to assess cell survival (Jafarian *et al.*, 2004). The resin extract of *A. heterophylla* growing in Egypt, had a significant cytotoxic activity against breast (MCF7) and colon (HCT116) cancer cell lines (Abdel-Sattar, 2009). The essential oil extracted from the leaves of *A. heterophylla* gathered in Egypt was found to have promising anticancer properties (Elkady and Ayoub 2018).

5.5. Insecticidal activity:

Foliar application of *T. orientalis* semi-solid crude extract on maize was highly efficient against *Chilopartellus* (Anju and Sharma 1999). *T. orientalis* leaf extracts have a repelling effect on *Chilopartellus*. The ether extract (68.63 percent) and acetone extracts (67.51 percent) of *T. orientalis* have sufficient repelling properties (Dwivedi and Shekhawat, 2004). *Juniper* species were used as insect repellents (Gao *et al.*, 2004). Due to its aromatic fragrance, toxicity, and insect repellency, clothing moths (Huddle and Mills, 1952), flour beetles (Sighamony *et al.*, 1984), cockroaches (Appel and Mack, 1989), and ants are all known to avoid Eastern Red Cedar wood (Thorvilson and Rudd, 2001). Cedar wood oil was discovered to repel termites (Zhu *et al.*, 2001). McDaniel and Dunn (1994) also showed the reduced termite attack by use of *J. virginiana* extracts.

5.6. Hair growth promoting activity:

T. orientalis use is thought to promote hair growth (Zhu *et al.*, 2004). It has been used in East Asia for decades to treat individuals with baldness and hair loss. In telogenic C57BL/6 N mice, Zhang *et al.* (2013) discovered that a hot water extract of *T. orientalis* stimulated hair development by initiating the anagen phase (Zhang *et al.*, 2013). *C. revoluta* also showed hair growth promoting activity (Hang *et al.*, 1998),

5.7. Anthelmintic activity:

Jaiswal *et al.*, (2011) investigated the anthelmintic effect of an ethanolic extract of *T. orientalis* leaves against *Pheretima posthuma* for the first time. The time of paralysis and death of the worm were determined using three concentrations of extract (1 percent, 2.5 percent, and 5%). The extract has anthelmintic action that was dose dependant (Sutar *et al.*, 2010).

5.8. Protective activity of gastrointestinal tract:

According to Dubey and Batra (2008), the ethanol proportion of *T. occidentalis* in both acute and chronic liver-induced HCV, showed hepatoprotective effects. The ethanolic fraction of *T. sativa* was discovered by the same team. *T. occidentalis* inhibits gastric lesions significantly. *Cycas revoluta* has been used as a traditional medicine to treat gastrointestinal distress (Negmet *et al.*, 2016).

CONCLUSION

The importance of microbial and oxidative damage to health as a fundamental determinant in human illness is growing, highlighting the need for new bioactive compounds, particularly from natural sources. Scientists from various fields around the world are investigating plants, identifying novel biologically active molecules, and using criteria such as antioxidant activity and antibacterial properties of plants, which is most industrious in the area of drug discovery. Recognizing the importance of pharmacologically important phytochemicals using plant derived principles, as well as the limitations of our current knowledge on the bioactivity potential status of gymnosperms, it is desirable to assess these plant groups for their pharmacologically important phytochemicals. Thus in this review the potentiality of five gymnosperm plants, namely – *Platydictylus orientalis*, *Araucaria heterophylla*, *Cycas revoluta*, *Thuja occidentalis* and *Juniperus virginiana* have been studied for their phytochemical composition. Many secondary metabolites produced by plants through diverse pathways, which have a significantly smaller molecular structure than primary molecules, have bioactive capabilities. These secondary metabolites are important components in the pharmacology industry's development of novel active agents and herbal products, and they are safer than synthetic pharmaceuticals (Harborne, 1973). The current study emphasizes the relevance of gymnosperms; yet, there is still much to learn about the numerous bioactive elements found in these plants that can aid in the development of treatments for a variety of disorders. It may be concluded that the six plants listed above are quite beneficial. These plants can be used to treat a variety of common and other various diseases. For their proper application, it is required to explore the maximum potential of these plants in the therapeutic sector and pharmaceutical sciences.

REFERENCES

1. Abdel-Sattar E., Abdel-Monem A.R., Ezzat S.M., El-Halawany A.M., Samar M. and Mounieir SM. (2009). Chemical and biological investigation of *Araucaria heterophylla* Salisb. Resin. *Zeitschrift für Naturforschung*, 64: 819-823.
2. Akers H. A., Abrego V. A., Garland E. Thujaplicins (1980). *Thujaplicins* as iron transport agents for *Salmonella typhimurium*. *J. Bacteriol*, 141(1):164-168.
3. Akkol E.K., İlhan M., Demirel M.A., Keles H., Tümen I., Süntar I. (2015). *Thuja occidentalis* L. and its active compound, -thujone: Promising effects in the treatment of polycystic ovary syndrome without inducing osteoporosis. *J. Ethnopharmacol*, 168: 25–30.
4. Angaji SA, Mousavi SF and Babapour E (2012). Antioxidants: A few key points. *Annals of Biological Research*, 3 (8): 3968-3977.

5. Appel AG, Mack TP (1989). Repellency of milled aromatic Eastern Red Cedar to domiciliary cockroaches (Dictyoptera: Blattellidae and Blattidae). *J Econ Entomol*, 82: 152–155.
6. Aslam, M.S., Choudhary, B.A., Uzair, M., Ijaz, A.S. (2013). Phytochemical and ethnopharmacological review of the genus *Araucaria*—review. *Pharm. Res*, 12:651–659.
7. Bellili S., Aouadhi C., Dhifi W., Ghazghazi H., Jlassi C., Sadaka C., El Beyrouthy M., Maaroufi A., Cherif A., Mnif W. (2018). The influence of organs on biochemical properties of tunisian *Thuja occidentalis* essential oils. *Symmetry*, 10: 649.
8. Biswas R., Mandal S.K., Dutta S., Bhattacharyya S.S., Boujedaini N., Khuda-Bukhsh A.R. (2011). Thujone-rich fraction of *Thuja occidentalis* demonstrates major anti-cancer potentials: Evidences from in vitro studies on A375 cells. *Evid. Based Complement. Altern. Med.*, 2011: 1–16.
9. Brijesh K., Ruchi R., Sanjita D., Saumya D. (2012). Phytoconstituents and therapeutic potential of *Thuja occidentalis*. *Res. J. Pharm. Biol. Chem. Sci.*, 3: 354–362.
10. Brown D. (1995). *Encyclopedia of Herbs and their Uses*.
11. Buben I, Karmazine M. Torjankova J and Nova D (1992). *Acta Hort*, 306.
12. Bucur V. (1995). *Acoustics of wood*. Boca Raton: *CRC Press*, 298.
13. Caragay AB. (1992). Cancer preventive foods and ingredients. *Food Technology*. 46:65.
14. Chanda S, Kaneria M and Vaghasiya KY (2011). Evaluation of antimicrobial potential of some Indian medicinal plants against some pathogenic microbes. *Natural Products and Resources*, 2: 225-228.
15. Clark AM, Mc Chesney, JD, Adams RP (1990). Antimicrobial properties of heartwood, bark/sapwood and leaves of *Juniperus* species. *Phytother. Res.*, 4: 15–19.
16. Dubey S.K. and Barta A. (2009). Antioxidant activities of *Thuja occidentalis* Linn. *Asian J. Pharm. Clin. Res.*, 2: 73–76.
17. Dubey S.K. and Batra A. (2008). Hepatoprotective activity from ethanol fraction of *Thuja occidentalis* Linn. *Asian J. Research Chem.*, 1: 32–35.
18. Dwivedi S. C., Shekhawat N. B. (2004). Repellent effect of some indigenous plant extract against *Trogoderma granarium* (Everts). *Asian J. Exp. Sci.*, 18:47-51.
19. Elkady W.M. and Ayoub I.M. (2018). Chemical profiling and antiproliferative effect of essential oils of two *Araucaria* species cultivated in Egypt. *Ind. Crops Prod.*, 118: 188–195.

20. Eller FJ, Clausen CA, Green F, Taylor SL (2010). Critical fluid extraction of *Juniperus virginiana* L. and bioactivity of extracts against subterranean termites and wood-rot fungi. *Ind Crop Prod.*, 329(3): 481–485.
21. Ellingwood F. (1919). Agents acting upon the genitourinary organs. In *The American Materia Medica, Therapeutics and Pharmacognosy*; Ellingwood, F., Lloyd, J.U., Eds.; *Eclectic Medical Publications: Portland, OR, USA*, 8–10.
22. Elshamy AI., Ammar NM., Hassan HA., Rowaily SL., Ragab TI., Gendy AE., Gawad AM (2020). Essential oil and its nanoemulsion of *Araucaria heterophylla* resin: Chemical characterization, anti-inflammatory, and antipyretic activities. *Industrial crops and products, Science Direct*, 148.
23. Essawi T. and Srour M. (2000). Screening of some Palestinian medicinal plants for antibacterial activity. *Journal of ethnopharmacology*, 70(3): 343-349.
24. Fassett, N.C. (1943). The validity of *Juniperus virginiana* var. *crebra*. *American J. of Botany*, 30(7): 469-477.
25. Fatima A., Naqvi S. B., Khaliq S. A., Perveen S. and Jabeen S. (2012). Antimicrobial susceptibility pattern of clinical isolates of *Pseudomonas aeruginosa* isolated from patients of lower respiratory tract infections. *Springerplus*, 1(1): 1-4.
26. Fischer M. M. and Bild M. (2019). Hospital use of antibiotics as the main driver of infections with antibiotic-resistant bacteria—a reanalysis of recent data from the European Union. *bioRxiv*, 553537.
27. Gao R., Gao C., Tian X., Yu X., Di X., Xiao H., Zhang X. (2004). Insecticidal activity of deoxypodophyllotoxin, isolated from *Juniperus sabinus* L., and related lignans against larvae of *Pieris rapae* L. *Pest. Manag. Sci.*, 60: 1131–1136.
28. Gupta G. and Srivastava A.K. (2002). In-vitro activity of *Thuja occidentalis* Linn. against human pathogenic aspergilli. *Homoeopath. Herit.*, 27: 5–12.
29. Hahn NI. (1998). Is Phytoestrogens Nature's Cure for What Ails Us? A Look at the Research. *Journal of the American Dietetic Association*, 98: 974-976.
30. Hamed MM., Ghareeb MA., Shafei AA., Abdel-aziz MS., Tolba SS. (2018). The In Vitro evaluation of antioxidant, anticancer and antimicrobial properties of *Araucaria heterophylla* grown in Egypt. *Pharmacology online*, 1: 221-235.
31. Hang HL, Nagatsu A, Okuyama H, Mizukami H, Sakakibara J (1998). Sesquiterpene glycosides from cotton oil cake. *Phytochem.*, 48: 665–668
32. Harborne J.B. (1973). *Phytochemicals Methods*. Chapman and Hall Ltd., London. 49-188.

33. Harnischfeger G., Stolze H. (1983). *BewährtePflanzendrogen in Wissenschaft und Medizin*. Notamed Verlag, *Bad Homburg/Melsungen.*, 250–259.
34. Huddle HB, Mills AP (1952). The toxicity of cedar oil vapors to clothes moths. *JEcon Entomol.*, 45: 40–43.
35. Irchhaiya R, Kumar A, Yadav A, Gupta N, Kumar S, Gupta N, Kumar S, Yadav V, Prakash A and Gurjar H (2015). Metabolites in plants and its classification. *World Journal of Pharmacy and Pharmaceutical Sciences*, 4(1): 287-305.
36. Jafarian-Dehkordi A., Emami S. A., Saeidi M., Sadeghi H. (2004). Cytotoxicologic studies of the extracts of Iranian *Juniperussabina* and *Platycladus orientalis* on cancer cells. *J. Res. Med. Sci.*, 5:205-209.
37. Jaiswal A., Kumar R., Kumar A., Kumar A. (2011). Antipyretic activity of *Platycladus orientalis* leaves extract in rat. *Int. J. App. Bio. Pharmaceut. Tech.*, 2(1): 250-251.
38. Jasuja N.D., Sharma S.K., Saxena R., Choudhary J., Sharma R., Joshi S. C. (2013). Antibacterial, antioxidant, phytochemical investigation of *Thujaorientalis*leaves. *J. Med. Plants Res.*,7(25):1886-1893.
39. Kawai S., Hasegawa T., Gotoh M., Ohashi H. (1994). 4-O-Demethylatein from the branch wood of *Thujaoccidentalis*. *Phytochemistry*,37:1699–702.
40. Khan UR, Mehmood S, Sherwani KS, Khan US, Khan A, Ullah I, Khan KD, Inam AS (2013). Study of chemical constituents and medicinal uses of ornamental species of District Bannu. *World J Publ*, 1: 173–198.
41. Kosuge T, Yokota M, Yosida M, Ochiai A. (1981). Studies on antihemorrhagic Principles in the crude drugs for hemostatics. I onhemostatic activities of the crude drugs for hemostatics. *YakugakuZasshi*, 101: 501-503.
42. Kowalska TM, Itzhak Y, Puett D (1995) Presence of aromatase inhibitors in cycads. *J Ethnopharm* 47:113–116.
43. Kuo YH, Yu MT (1993). A new lignan, fornoslactone, from the bark of *Juniperusforrnaosana* Hay var. *concolor* Hay. *Heterocycles.*, 36: 529–535.
44. Lal K, Ahmed N and Mathur A. (2017). Study of the antimicrobial profile and phytochemical composition of solvent extracts of leaves and female cones of *Cycas revoluta*. *Int J CurrMicrobiol App Sci.*,6(4): 2514-22.
45. Levy SB (2002). The antibiotic paradox: How the misuse of antibiotics destroys their curative powers. *Cambridge, MA: Perseus Publishing.*

46. Lin H. S., Yue B. D. and Ho P. C. (2009). Determination of pterostilbene in rat plasma by a simple HPLC-UV method and its application in pre-clinical pharmacokinetic study. *Biomedical Chromatography*, 23(12): 1308-1315.
47. Liu H. and Logan B. E. (2004). Electricity generation using an air-cathode single chamber microbial fuel cell in the presence and absence of a proton exchange membrane. *Environmental science & technology*, 38(14): 4040-4046.
48. Mabey RM, McIntyre P, Micheal G. Duff and Stevens J. (1998). The new age herbalist, Collier Books. Macmillian Publishing Company, New York, 55-56.
49. Madej T., Piro`znikow E., Dumanowski J., Łuczaj Ł. (2014). Juniper Beer in Poland: The Story of the Revival of a Traditional Beverage. *J. Ethnobiol.*, 34: 84–103.
50. Magda T. Ibrahim, Nevein M. Abdel-Hady and Lamiaa N. Hammad (2004). GC/MS Analysis and biochemical studies of the essential oil of *Thujaorientalis*L. growing in Egypt. *Bull. Fac. Pharm. Cairo Univ.*, 42(1).
51. Mandal MS, Migliolo L, Das S, Mandal M, Franco LO, Hazra KT (2012). Identification and characterization of a bactericidal and proapoptotic peptide from *Cycas revoluta* seeds with DNA binding properties. *J Cell Biochem*, 113: 184–193.
52. Marjorie C. (1996). Plant products as antimicrobial agents. *Clinical Microbiol. Rev.*, 12: 564-582.
53. McDaniel CA, Dunn BS (1994). Can wood extractives be used as wood protectants? *Proc. Symp. Curr. Res. Chem. Sc.i Gen. Tech. Rep. Soc.*, 101: 61–63.
54. Moawad A, Hetta M, Zjawiony JK, Ferreira D, Hifnawy M. (2014). Two new dihydroamentoflavone glycosides from *Cycas revoluta*. *Nat Prod Res.*, 28(1): 41-7.
55. Moon M. K., Kang D. G., Lee Y. J., Kim J. S. and Lee, H. S. (2008). Inhibitory activity of *Thuja orientalis* on TNF- induced vascular cell adhesion in HUVECs. *The FASEB Journal*, 22:1120-1128.
56. Mourya MK, Prakash A, Swami A, Singh GK, Mathur A. (2011). Leaves of *Cycas revoluta*: Potent antimicrobial and antioxidant agent. *World J Sci Technol.*, 1(10): 11-20.
57. Nair JJ, Staden JV (2012). Isolation and quantification of the toxic methylazoxymethanol glycoside macrozamin in selected South African cycad species. *South African J Bot.*, 82: 108–112.
58. Nash, E.B. (2002). Expanded Works of Nash Hardcover. *B Jain Publishers Pvt Ltd.: Noida, India.*

59. Nazir M.Z., Chandel S., Sehgal A. (2016). In vitro screening of antioxidant potential of *Thuja occidentalis*. *J. Chem.Pharm. Sci.*, 8: 283–286.
60. Negmetal AW, Ibrahim AERS, Kamilia AAES, Ghada IA, Amany ER (2016). GC-MS analysis of petroleum ether extract and volatiles of *Cycas revoluta* Thunb growing in Egypt. *Invent Rapid Planta Act*, 201: 1–5.
61. Nemeth E.Z., Nguyen H.T. (2020). Thujone, a widely debated volatile compound: What do we know about it? *Phytochem. Rev.*, 19: 405–423.
62. Nizam I., Mushfiq M. (2007). Antioxidant activity of water and alcohol extracts of *Thuja orientalis* leaves. *Orient. Pharm. Exp. Med.*, 7(1):65-73.
63. Okwu, D.E. (2004). Phytochemicals and vitamin content of indigenous species of southeastern Nigeria. *J.Sustain. Agric.Environ.*, 6(1): 30-37.
64. Panhong A, Kanjanapothi D and Taylor WC. (1986). Ethno botanical review of medicinal plants from Thai traditional books. Part I: Plants with anti-inflammatory, anti-asthmatics and anti-hypertensive properties. *Journal of Ethno pharmacology*, 18: 213-228.
65. Prakash V., Kaur H., Kumari A., Kumar M., Bala R. and Gupta S. (2020). Phytochemicals and biological studies on *Cycas revoluta* Thunb, *Advances in Traditional Medicine*, 21: 389–404.
66. Radha P., Udhayavani C. and Nagaraj R. (2018). A Comprehensive Review on Medicinally Important Gymnosperms Mentioned in Siddha. *Journal of Research in Siddha Medicine*, 1(1): 23.
67. Safwat G. M., Hamed M. M., Moatamed S. A. (2018). Studies of the biological activity of *Cassia fistula*. *Pharmacology online*, 1: 75-85.
68. Seca, A. M., & Silva, A. M. (2006). The chemical composition of the *Juniperus* genus (1970–2004). *Recent progress in medicinal plants*, 16, 401-522.
69. Shi J, Arunasalam K, Yeung D, Kakuda Y, Mitta G and Jiang Y. (2004). Saponins from edible legumes: chemistry, processing, and health benefit. *J Med Food.*, 7: 67-78.
70. Sighamony S, Anees I, Chanrakaka T, Osmani Z (1984). Natural products as repellents for *Tribolium castaneum* Herbst. *Int Pest Control*, 26: 156–157.
71. Silva I.S., Nicolau L.A.D., Sousa F.B.M., de Araújo S., Oliveira A.P., Araújo T.S.L., Souza L.K.M., Martins C.S., Aquino P.E.A., Carvalho L.L., et al. (2017). Evaluation of anti-inflammatory potential of aqueous extract and polysaccharide fraction of *Thuja occidentalis* Linn. in mice. *Int. J. Biol. Macromol.*, 105: 1105–1116.
72. Sindhi V, Gupta V, Sharma K, Bhatnagar S, Kumari R and Dhaka N (2013). Potential applications of antioxidants - A review. *Journal of Pharmacy Research*, 7: 828-835.

73. Sodipo O.A., Akiniyi J.A. and Ogunbamosu J.U. (2000). Studies on certain on certain characteristics of extracts of bark of *Pansinystaliamacruceras* (K schemp) picrreExbeille. *Global J. Pure Appl. Sci.*, 6: 83-87.
74. Stan M.S., Voicu S.N., Caruntu S., Nica I.C., Olah N.K., Burtescu R., Balta C., Rosu M., Herman H., Hermenean A. *et al.* (2019). Antioxidant and anti-inflammatory properties of a *Thuja occidentalis* mother tincture for the treatment of ulcerative colitis. *Antioxidants*, 8: 416.
75. Sutar N., Garaj R. *et al.* (2010). Anthelmintic activity of *Platycladus orientalis* leaves extract. *Int. J. Parasit. Res.*, 2(2):01-03.
76. Takoa k, Hitoshi I and KakaoS.End L. *Chem. (1995).Pharm. Bull*; 33(1): 206-209.
77. Tanveer M. Z., Javeed A., Ashraf M., Rehman M. U., Anjum S. M. M. (2015). Evaluation of anti-inflammatory and analgesic potential of aqueous methanolic extract of *Thuja orientalis* in albino rats. *J. Ani. Pl. Sci.*, 25(4):1183-1186.
78. Thieret, J. W. (1958). Economic botany of the cycads. *Economic Botany*, 12(1): 3-41.
79. Thorvilson H, Rudd B (2001). Are landscaping mulches repellent to red imported fire ants? *Southwest Entomol.*, 26: 195–202.
80. Tirapelli CR, Ambrosio SR, da Costa FB, de Oliveira AM. (2008). Diterpenes: a therapeutic promise for cardiovascular diseases. *Recent Pat Cardiovasc Drug Discov.*, 3(1): 1-8.
81. Treare GE and Evans WC. (1985). *Pharmacognosy* 17 edn, BahiveTinal, London.149.
82. Tumen I, Süntar I, Eller FJ, Kele H, Akkol EK (2013). Topical wound-healing effects and phytochemical composition of heartwood essential oils of *Juniperus virginiana* L., *Juniperus occidentalis* Hook., and *Juniperus ashei* J. Buchholz. *J Med Food*, 16(1): 48-55.
83. Usha Rani P. and Jyothsna Y. (2010). Biochemical and enzymatic changes in rice plants as a mechanism of defense. *Acta Physiologiae Plantarum*, 32(4): 695-701.
84. Van Haverbeke D. F. and Read R. A. (1976). *Genetics of eastern redcedar* (Vol. 32). Department of Agriculture, Forest Service.
85. Veitch G.E., Boyer A. and Ley S.V. (2008). The Azadirachtin Story. *Angew. Chem. Int. Ed.*, 47: 9402-9429.
86. Wang T. Y., Li Q., and Bi K. S. (2018). Bioactive flavonoids in medicinal plants: Structure, activity and biological fate. *Asian journal of pharmaceutical sciences*, 13(1): 12-23.

87. Wang XQ and Ran JH. (2014). Evolution and biogeography of gymnosperms. *Molecular Phylogenetics and Evolution*. 75: 24-40.
88. Witte L., Berlin J., Wray V., Schubert, W., Kohl W., Höfle G., Hammer J. (1983). Monoundditerpenes from cell cultures of *Thuja occidentalis*. *Planta Med.*,49: 216–21.
89. Yesenofski, J. (1996). Juniper Oil Distillation and Marketing Project Western Juniper Commercialization Program Final Report, Ver. 2. The Confederated Tribes of the Warm Springs Reservation of Oregon, Business & Economic Development Branch.
90. Zaffar M, Munis MFH, Rasul F, Masood S, Hassan SW, Imran M, et al. (2014). Biological assays of plant extracts from *Araucaria columnaris* and *Cycas revoluta*. *J Food Agric. Environ.*, 12(1): 128-31.
91. Zhang N. Park D.K, Park H.J. (2013). Hair growth-promoting activity of hot water extract of *Thuja orientalis*. *BMC Complement. Alternat. Med.*, 13(9):1-13.
92. Zhu BCR, Henderson G, Chen F, Fei H, Laine RA (2001). Evaluation of vetiver oil and seven insect-active essential oils against the Formosan subterranean termite. *J Chem Ecol.*, 27: 1617–1625.
93. Zhu J.X., Y. Wang and L.D. (2004). Kong. Effects of Biota orientalis extract and its flavonoid constituents, quercetin and rutin on serum uric acid levels in oxonate-induced mice and xanthine dehydrogenase and xanthine oxidase activities in mouse liver. *J. Ethnopharmacol*, 93: 133–140.