Nature's Defense: Medicinal Plants as Neuroprotective and Hepatoprotective Agents

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SUMMARY

Throughout history, medicinal plant extracts have been utilized for fulfilling the nutritional necessities of individuals and providing therapeutic effects such as anti-microbial, anxiolytic, anti-inflammatories, anti-depressive, anti-apoptotic, antioxidants, and anti-cancer properties. The amalgam of Western and Eastern medicine raises novel probabilities in the medicinal field. The liver is a crucial organ necessary for metabolizing and clearing the blood from waste metabolites thus purifying the blood. Neurotoxicity can increase the incidence of chronic cognitive impairment, memory problems, and defective motor control. Several plants like *Mangifera indica*, *Convolvulus arvensis*, *Caesalpinia crista*, *Salix caprea* and *Trianthema decandra* have been explored for their hepatoprotective action. Similarly, neurodegenerative disorders such as Parkinson’s disease, Alzheimer’s disease, and Huntington’s disease; and neurobehavioral diseases such as depressive disorders and anxiety have been characterized as a severe challenge for a healthy society affecting people’s lifestyle aspects. Medicinal plants such as *Ginkgo biloba*, *Panax ginseng* C.A. Meyer, *Chrysanthemum* spp., and *Scutellaria baicalensis* Georgi have been explored for their neuro-protective action in combating disorders like Parkinson’s and Major depressive disorder.

INTRODUCTION

Since the antediluvian times, people have been working on searching and improving their remedies for the ailments and pandemics that broke out in those periods. The constant use of medicinal plants and evolvement in the remedies over time prompted the discovery and invention of many new herbal remedies involving multiple combinations for the therapeutic management of various diseases (Benkhnigue et al., 2023). However, it’s obvious that with the consistent evolvement in the disease etiology, the advancements in the treatments are also critical for public health management and the prospering of a healthy society (Chaughule & Barve, 2024). Similarly, with the excess provided to the researchers to the unreachable regions of the world with constant natural flora, modern science has been able to discover many new compounds. Various plant based products have been prepared after evaluating their effects in either through simple or multiple extracts and checking their therapeutic efficacy in the clinical trials. Despite the popular use of occidental medicines for treatment of the major organ impairments or body dysfunction, the medicinal herbs were never secondary to any other medicinal system when it comes to treatment (Rehman et al., 2021). Since the start of the 21st century, due to the immense adverse effects of Western medicines, herbal medicines are gaining more recognition among researchers for their less adverse effects and much better efficacy. This can be accredited to the complex amalgam of phytochemical constituents present in a particular manner, thanks to the nature (Zhang et al., 2015). Now the researchers are focusing more on extracting the natural phyto-constituents or preparing the herbal extracts of plants to test their affectivity and develop their safety profile for disease prevention and treatment, and to boost the immune system (Olaiya et al., 2016). Keeping the scenario in view, some of the recently discovered medicinal plants are mentioned here with a brief description of their mode of action.

ROLE OF MEDICINAL PLANTS IN PROTECTING ORGAN HEALTH

Since the existence of human beings on Earth, they have been accompanied by earthly flora. Hundreds and thousands of plants are used across the globe for therapeutic purposes in different cultures. That’s because they are reservoirs of many active phytoconstituents with numerous protective and immune-boosting effects such as their ability to ameliorate, heal, restore and boost the functioning of the major body organs such as the liver, kidney, gastrointestinal tract, etc. (Mendoza & Silva, 2018). Different regions including Japan, China, India, Pakistan, Korea, Malaysia etc. have their own cultural and traditional systems in which the local herbal

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practitioners have developed their herbal remedies and medicinal formulations (Bathaie et al., 2015). Its a non-negotiable fact that origin of the Western medicine is also from plants and their constituents which are refined and structure analyzed to prepare analogs in the laboratory (Farzaei et al., 2018). However, the initial inspiration for the derivation of most of the therapeutic drugs is attained from the plants. However, after great consumption of occidental medicines for hepatic and neuronal diseases throughout the 20th century, long-term side effects and ADRs (adverse drug reactions) have been observed. These facts have also led to the increased preference for herbal medicines by patients particularly in the 21st century (De Luca, 2012). This is the reason why more than 60% of the patients in the Western world (UK and USA) have been using herbal products for hepatic, nephritic and neuronal diseases. Plants are their preference not only because of their cost-effectiveness but also due to their multi-functioning ability, biochemical diversity, lesser side effects and reduced withdrawal effects contrary to Western medicines (Shah & Iqbal, 2018).

OXIDATIVE STRESS: A GENERAL PHENOMENA IN DISEASES

Oxidative stress is one of the most common processes that are linked to the majority of diseases (Gruys et al., 2005). The process is induced due to disruption in the balance of anti-oxidants and free radicals (Abd-Ellah et al., 2011). Another major factor contributing to oxidative stress is the formation of unstable molecules referred to as Reactive Oxygen Species (ROS), which are a bunch of free radical molecules such as hydroxyl radical, nitric oxide (NO), hypochlorous acid and many more (Shcherbik & Pestov, 2019). The molecules with possession of one electron in their valence shell are perfectly capable of causing tissue damage by having chemical interactions with the tissue lipids, genetic expression and proteins (Zhong & Yin, 2015). The damage usually initiates with tempering to the structure of amino acid residues such as cysteine, histidine, tyrosine, glycine etc. eventually causing the structural fluctuations in the basic structural design of proteins (Uchida, 2003). ROS also leads to lipid peroxidation by attacking the phospholipids present in the plasma membranes of the cells (Diamanti-Kandarakis et al., 2017). The reactive aldehydes that are critical biomarkers in the characterization of oxidative damage such as 4-hydroxynonenal (HNE) and malondialdehyde (MDA) then lead to the production of protein-cross-linkages subsequently causing the Glutathione mitigation, peroxide generation and induction of cytotoxicity (Srinivas et al., 2019). ROS also plays a role in causing conformational changes in DNA such as nucleotide deletion and other genetic mutations. Not only that, but the ROS can also modulate several kinds of kinases (cytokines etc.), transcription factors associated with pro-inflammatory markers (interleukins, interferons and tumor necrosis factor-alpha) and prostaglandins (Ranneh et al., 2017).

HEPATIC DISEASES

The liver is one of the vital body organs with its multi-functional abilities. Not only it is responsible for metabolizing a major proportion of the administered biochemical constituents and drugs but also plays a leading role in the excretion of waste chemicals (Akinloye & Olaniyi, 2011). Moreover, the liver is the primary destination site for toxins that appear in the intestines, and the liver bears the responsibility for its breakdown and clearance from the body via urine. Additionally, it also serves as a storage region for several substances such as vitamins, iron, minerals, and glycogen. Therefore, it has to replenish the body's energy needs in case of fasting or hypoglycemia by breaking down glycogen to glucose from storage reservoirs and supplying instant energy to the body (Rane et al., 2016). It is also responsible for detoxifying chemicals, alcohol, drugs, infectious organisms, heavy metals, and waste metabolites from the bloodstream (Arman et al., 2022).

Furthermore, the liver is responsible for disposing of worn-out cells (like RBCs, etc.), and waste products e.g. microbes, viruses, drugs, and alcohol (Nayak et al., 2011). The liver also transports and distributes the substances after metabolizing them into the bloodstream, and works in coordination with all major organs of the body. It secretes cholesterol and bile, which is crucial for digestion and emulsification of oils, fats, and vitamins. The disability of dysfunction of hepatic cells can lead to acute complications like hepatic carcinoma, liver failure, hepatic necrosis, and chronic illnesses such as hepatitis (Adeneye et al., 2015). Many plants have been explored

Table 1. Phytochemical constituents and Pharmacological effects of Hepatoprotective plants

Botanical name	Active constituents	Pharmacological effects	References
Mangifera indica	Polyphenolic glucosyl xanthones, mangiferin, vimang, 2,3,4,6-penta-O-galloyl-β-D-glucopyranose, gallic acid, methylgallate	Restores the elevated levels of serum alkaline phosphatase (ALP), aminotransferases, fasting blood glucose (FBG), malondialdehyde (MDA), and bilirubin.	Omotayo et al., 2015
Convolvulus arvensis	Quercetin, meso-cuscohygrine, tropine, pseudotropine, tropinone, palmitic acid, stearic acid	Restores the level and efficacy of hepatic enzymes and total bilirubin	Al-Snafi, 2016
Caesalpinia crista	2 hydroxytrideca-3,6-dienylpentanoate, octacosa-12,15 diene, 3-O-methyl ellagic acid, 3′O-α-rhamnopyranoside, β-sitosterol	Increase in hepatic iron and serum ferritin levels, and also exhibited inhibition of lipid peroxidation, and hepatic fibrosis. Modulated DPPH radical scavenging and prevention from Fe2+-mediated oxidative DNA damage.	Upadhyay et al., 2019
Salix caprea	Quercetin, rutin, luteolin-7-glucoside, hexahydrofarnesylacetone, 2-butyl-octanol, and 2-hexyl-1-octanol	Scavenging of H2O2 and NO, reduction of GSH, Lipid peroxidation, restoration of TNF-α and NF-kB levels, and modulating various liver enzyme activity	Alam et al., 2006
Trianthema decandra	hydroxy-2-methoxy benzaldehyde, 5,2′-dihydroxy-7-methoxy-6,8-dimethylflavone, sitosteroI glucoside and stigmasterol glucoside	Restores the levels of Alanine amino transferase (ALT), Aspartate amino transferase (AST) and Bilirubin	Sengottuvelu et al., 2008

recently for their exceptional hepatoprotective effects (Table 1).

Mangifera indica

Mangifera (*M.*) *indica* L. commonly known as Mango is an important tropical fruit throughout the world, with India, Pakistan, and Africa being the major contributors to its production. Besides being the national fruit of Pakistan, it is named the "king of fruits" in both Pakistan and India (Ilukho et al., 2022). The plant has several therapeutic properties. Extracts from several parts of the mango tree like leaves, roots, bark and fruit contain high concentrations of mangiferin, which is a potent flavonoid with a lot of pharmacological properties (Omotayo et al., 2015). In the traditional Ayurvedic system, it is usually prescribed by traditional medicinal practitioners for the amelioration of indigestion and reducing acidity because of its antioxidative effects. Furthermore, its other parts are in use for therapeutic management of insomnia, jaundice, asthma and diarrhea (Adeneye et al., 2015).

Polyphenolic compounds such as mangiferin and vimang separated from *M. indica* are responsible for their efficacious gastro-protective, anti-microbial, anti-oxidative and hepato-protective impact (Arman et al., 2022). For example, in a pharmacological analysis, the aqueous stem-bark extract of a mango tree elicited the ameliorative effect when tested against the carbon tetrachloride (CCl4) induced hepatic necrosis by repressing the elevated levels of alkaline phosphatase (ALP), Fasting Blood Glucose (FBG), aminotransferases, bilirubin and malondialdehyde [MDA (Batool et al., 2018)]. Additionally, it increases the levels of biomarkers that decrease hepatic dysfunction such as super dismutase, high-density lipoprotein cholesterol (HDL-C), total protein, albumin, low-density lipoprotein cholesterol (LDL-C), catalase and GSH (glutathione). These biological activites may be due to its anti-oxidation and reduced lipid peroxidation (Ali et al., 2013).

Convolvulus arvensis

Convolvulus (*C.*) *arvensis* is a member of the Convolvulaceae family. It is usually named as bindweed, which is an evergreen herbaceous plant that grows in temperate regions like Pakistan, Bangladesh and India (Al-Snai et al., 2019). Since the 18th century, the plant has been popular for traditional health practices. The weed consists of several therapeutic characteristics like; wound curer, purgative, cathartic, anti-spasmodic and anti-inflammatory (Ragab et al., 2023). Furthermore, it can also treat cough, dandruff, spider stings and flu. Additionally, it has a lot of cytoprotective, hepatoprotective, anti-microbial, immune-modulatory and anti-oxidative effects (Al-Snai et al., 2019).

Though past research has mostly focused on revealing the anti-arthritic activity of plants due to the presence of several glycosides, tannins, terpenoids, saponins and alkaloids (Saleem et al., 2015), this plant is usually used as an effective laxative. However, its extract is also potent for managing conditions like flu, cough and jaundice. Furthermore, it also provides assistance in the management of pallor, oedema, inflammation, gout and joint pain (Khaliq et al., 2022). In the research study conducted by Ali et al. (2013), the hepatoprotective potential of ethanolic extract from plant showed prospective findings in paracetamol-induced hepatotoxic rats. The prominent phytochemical substances (kaempferol and quercetin) of *C. arvensis* are accredited to its hepatoprotective effect (Mishra et al., 2015).

Caesalpinia crista

Caesalpinia (*C.*) *crista*, a broad perennial shrub, belongs to the legume family and is usually referred to as Karanja in Indian regions (Upadhyay et al., 2019). Just like other members of the Fabaceae family, *C. crista* also has a variety of phyto-contituents including glycosides, saponins, alkaloids and flavonoids (Sarkar et al., 2012). The plant has many therapeutic properties such as anthelmintic, anti-malarial, anti-inflammatory, anti-periodic, anti-diabetic, and antipyretic effects. In a pharmacological analysis done by Mishra et al. (2015) the ethanolic extract of *C. crista* leaves was tested for its hepatoprotective potential against paracetamol-induced hepatotoxicity in rats under controlled circumstances of laboratory (SODHI et al., 2023). The extract depicted a noteworthy reduction in the increased values of TGA (triglycerides), TB (tuberculosis) and serum marker enzymes compared to the positive control group. The findings helped in developing the theory that *C. crista* leaf extract has extensive potential for hepatoprotective activity against hepatotoxic conditions (Mishra et al., 2014).

Salix caprea

Mostly recognized as goat willow and pussy willow by the common folks. *Salix* (*S.*) *caprea* is a member of the Saliaceae family and has been largely distributed in Western Asia, Europe and Central Asia (Tawfeek et al., 2021). Previous investigations have exhibited that plant has many medicinal qualities, particularly anti-oxidant and anti-inflammatory properties (Wahid et al., 2016). The conventional practitioners have been treating digestion issues, headaches (migraine, etc.), constipation and other ailments in both animals and humas using (Tawfeek et al., 2021). The Phenolic compounds and several flavonoids have been found in the various plant extracts during qualitative study. The prominent flavonoids such as quercetin, rutin and luteolin-7-glucoside were found in the plant whereas major phenolic compounds are catechins and salignin (Salehi et al., 2019). Another pharmacological investigation performed by the Wahid et al. (2016) proved the hepatoprotective activity of this plant. He used the ethanolic extract of the Willow flower in rats against CCl4-induced hepatoxicity (Ahmed et al., 2011). The ethanolic extract of the plant flowers restored the concentration of enzymatic activity in serum, assuring that the extract is entirely potent and can restore the structure of neuronal plasma membrane and ameliorating the liver injury done by CCl4. The hepatoprotective action is accredited to its anti-oxidant activity (Alam et al., 2006).

Trianthema decandra

One prominent species of weed in the Aizoaceae family is *Trianthema* (*T.*) *decandra* (Geethalakshmi et al., 2010). The plant is native to tropical and subtropical parts of the world, including Africa, Australia, India, and so on. In Hindi and Tamil, the plant is commonly referred to as Gdabani and Vellai Shaaranai, respectively (Kumar et al., 2004). The plant is a reservoir for many phytoconstituents for instance, various investigations approved the root extract of plants for their role in managing chronic respiratory ailments, orchitis, and hepatic damage. Moreover, aperient properties were found in the root bark decoction of this incredible plant (Kumar et al., 2017). The pure liquid obtained from leaves can be used to ameliorate migraine and headaches (Balamurugan & Muthusamy, 2008). Another species of the same plant genus i.e. T. portulacastrum has also demonstrated the hepatoprotective effect and can play an effective role in managing edema of the spleen and liver (Pancholi, 2023). In another pharmacological investigation, the leaf extract of *T. decandra* was analyzed in paracetamol and thioacetamide-induced hepatotoxicity (Sengottuvelu et al., 2008). It improved the hepatic condition by promoting lipid peroxidation leading to a significant reduction in various biomarkers such as GST, CAT, GPX, and GSH-R (Mandal et al., 1997). This hepatoprotective effect of plant leaves is accredited to its role in the betterment of protein production, boosting hepatic regeneration and intensifying detoxification of toxic metabolites (Mandal et al., 1997).

NEUROLOGICAL DISORDERS

Neurodegenerative diseases also include conditions such as Huntington's disease, Alzheimer's disease, and Parkinson's disease, for which a common pharmacological change includes the accelerated degeneration of neurological cells, and the phenomenon is observed in adulthood or patients above the age of 50 (OCED, 2017). The World Health Organization (WHO) also reported that the usual life span can be increased by encouraging people to follow disease preventive prevention guidelines and timely diagnosis of the ailment. Since cognitive impairment develops and progresses fast with aging due to a decrease in neurodegenerative functions, the load of neurodegenerative ailments falls upon society, affecting it both economically and mentally (Liu et al., 2020). However neuro-behavioral diseases are also common in society affecting public mental health, and it is equally affecting people of all age groups ranging from childhood to adulthood such as Major Depressive Disorder, Manic disorders which occur concurrently with dementia-like memory-declining diseases. Whenever it comes to neurological disorders, many controversies are found in the use of occidental or traditional medicinal plants for their underdeveloped safety profiles and therapeutic doses (Galts et al., 2019). Albeit, most aged patients prefer natural plant extracts, or in other words, they approach the traditional medicinal system for treating their health problems, because think of them as the most cost-effective and pure therapeutic remedies contrary to the extremely refined western medicine having numerous side effects (WHO, 2017).

Thus, the pharmaceutical industry is focusing on the research and development of new herbal therapeutic products. Several plants have been found to possess the neuroprotective potential (Table 2) to treat the neuro-psychiatric, neuro-behavioral, and neurodegenerative conditions (Marras et al., 2018). Though the selected medicinal species are very few compared to the vast flora and extensive research conducted on the plants, these plants exhibited promising effects during their in vivo and in vitro pharmacological trials regarding the above-mentioned conditions and anxiety disorders. Considering the elevating incidence of these disorders particularly related to mental health in the past two decades, there is a dire necessity to establish health policies and build customized therapeutic strategic plans. For instance, Alzheimer's disease is the most popular form of dementia occurring in 60% to 70% of memory ailment cases characterized by symptoms such as memory loss and cognitive degeneration. Moreover, around 10 million individuals are reported across the globe with the diagnosis of Parkinson's disease leading to loss of voluntary actions and motor control. Furthermore, about 6 average patients are characterized with Huntington's disease among every 100,000 individuals, which is a genetic neurological disorder (Baake et al., 2017). A significant increment in depression-diagnosed individuals observed since the start of the 20th century with a noteworthy rise in Major depressive disorder and intense anxiety. Neurodegenerative ailments have complex etiology with overlapping mechanisms, most of which are yet to be discovered in their exact manner of occurrence (Moreira et al., 2023. However, oxidative damage, Neurological inflammation, and disrupted balance of neurotransmitters complicate the therapeutic management plans (Duthey, 2013).

Scutellaria baicalensis

The plant belongs to the Lamiaceae family and is a well-known medicine used in conventional medicinal systems. For instance, its dried root is prescribed for common health problems such as dysentery, asthma, hypertension, diarrhea, and numerous neurological disorders (Zhao et al., 2016). It contains numerous phytochemicals and all of them neither have nor been discovered yet but major bioactive chemicals probably responsible for its medicinal effects include wogonoside, baicalein, wogonin, and baicalin. It has been revealed in a recent study that was conducted to analyze the effect of various *Scutellaria* (*S.*) *baicalensis* extracts against Alzheimer's disease (Delerue et al., 2021). It was suggested that aqueous extract demonstrated average performance regarding the blockage of Acetylcholinesterase (AChE), contrary to the ethanolic extract which presented far more efficient activity in improving the condition of inflammatory neurons and oxidative damage by decreasing the impact of cyclooxygenase 2 (COX-2) and nitric oxide synthase (iNOS) (Jeong et al., 2011).

Another study performed to check the effect of Baicalin phytoconstituents revealed that it promotes neuronal cell division on crossing the Blood-brain Barrier (BBB) suggesting its potent working against neurogenesis. In further experimentation conducted in rat brains to unveil Baicalein's mode of action, its prominent effect on the betterment of cellular respiration was found suggesting its neuroprotective activity (Cheng et al., 2008). Furthermore, it also boosts the reduction in neuroblastoma cells and enhances the growth of neurites in dopamine-like cells (Li et al., 2012). Another in-vivo study suggested that baicalein is also potent against Parkinson's disease since it outnumbered the disease

Table 2. Phytochemical constituents and Pharmacological effects of Neuroprotective plants

Botanical name	Active constituents	Pharmacological effects	References
Scutellaria baicalensis	Baicalin, wogonoside, baicalein and wogonin	Improves neuroinflammation and cognitive damage, decreases COX-2 effect	Zhao et al., 2016
Panax ginseng	Ginsenosides (key compounds: Rg1, Rg5, Rc and Rb1), ginseng	Dopamine production, decreases apoptosis, stimulates GABA receptors to regulate the over-activation of excitatory plasma membrane receptors	Hong et al., 2013
Chrysanthemum	Caffeoylquinic acids, 3,5-dicaffeyol-epi-quinic acid, terpenes, flavinoids, luteolin and acacetin	Free radical scavenging, improves cognitive skills and memory impairment, decreases activity efficacy of acetylcholinesterase (AChE)	Shahrajabian et al., 2019
Bambusa vulgaris	Luteolin, caffeic acid, p-coumaric acid, caffeic acid, ferulic acid, cholinergic acidvitexin, and orientin	Scavenging effect against ROS, inhibits tyrosinase, increases dopamine release	Wróblewska et al., 2018
Ginkgo biloba	Ginkgolides and bilobalide	Relieves oxidative stress, ameliorates functional efficacy of mitochondria, blocks neural cell death and promotes neurogenesis, stimulates cerebral blood flow	Liang et al., 2020

symptoms effectively, enhanced dopamine cell survival, and decreased muscular tremors. Furthermore, it also ameliorated the oxidative damage in neurotoxic mice alongside improved motor effect. Additionally, it can also repress the oligomerization of alpha-synuclein thus leading to betterment of the Parkinson’s disease by lowering the toxicity levels (Lu et al., 2011). The studies emphasize the effective neuroprotective action of baicalein and baicalin, suggesting its promising future in preparing new treatment plans for neurological ailments (Fernandes et al., 2022).

Panax ginseng

Panax (*P.*) *ginseng*, being the primary source of commercial ginseng, is a medicinal herbal plant used since the 19th century as a major component of East Asian regions (Ren & Zuo, 2012). It possesses various therapeutic properties and can be used in the management of auto-immune diseases, diabetic conditions, aging effects, wound healing, and cancer (Hong et al., 2013). These medicinal benefits are accredited to its immense reservoir of more than 185 ginsenosides, which depict numerous pharmacological impacts on the CNS or central nervous system, thus leading to cognitive repair, lowered inflammation and oxidative stress in neurons and ameliorating neurodegenerative ailments (Ru et al., 2015). The pharmacological analysis of *P. ginseng* improved its anti-oxidant characteristics. For example, previous research suggested the free radical scavenging activity of the *P. ginseng* extracts thus approving it for intense management of high oxidative stress (Hu et al., 2011).

Furthermore, it also demonstrated encouraging results regarding future perspectives in neurodegenerative conditions like Alzheimer’s disease, Parkinson’s disease and Huntington’s disease by repressing activity of some enzymes. Moreover, it has elicited efficacious anxiolytic and anti-depressant effects (Van Kampen et al., 2003). In addition, Ginsenosides have shown betterment of neuronal condition by repressing the aggregation of many proteins (tau proteins, alpha synuclein, lewy body, etc.) and promoting dopamine production and release, which is crucial for proper motor performance (Radad et al., 2004). Specific ginsenosides like Rg1 and Rb1 are also presumed to enhance cell’s functional capability and reduce neural cell death in lab animal test subjects infected with Parkinson’s disease (Jin et al., 2017). Ginsenosides also promote an extensive number of different neurotransmitter systems like GABA receptors and adenosine receptors to mitigate the over-activation of excitatory plasma membrane receptors thus causing potent neuroprotective effects (Yin et al., 2011). Moreover, it also promotes the formation of new neurons by stimulating the BDNF or brain-derived neurotrophic factor pathway (Shin et al., 2009).

***Chrysanthemum* spp.**

Some members of *Chrysanthemum* (*C.*) spp. flowers such as *C. indicum* and *C. morifolium* are popular for their excessive therapeutic effects such as immunomodulatory, anti-tumor, anti-bacterial, and anti-oxidant characteristics (Yoshikawa et al., 2000). Among these, the anti-oxidant is one of the prominent therapeutic effects of the later-mentioned species, accredited to the presence of various flavonoids, caffeoylquinic acids, and terpenes (Kim & Lee, 2005). Previous pharmacological investigations indicate the particular compounds of *C. morifolium* due to its free radical scavenging, eliciting anti-oxidative effects. Another study conducted in recent years explored the neuroprotective characteristics of *C. indicum* particularly in the Alzheimer’s induced mice subjects (Yuan et al., 2015).

The clinical investigation showed that aqueous extract of plant petals showed ameliorated cognitive functioning and improved the memorizing ability in scopolamine-induced amnesic test subjects (Choi et al., 2016). The major phenolic compounds like luteolin and acacetin were responsible for their intense cognitive advantages, with extracts depicting decreased intrinsic efficacy of acetylcholinesterase (AChE) contrary to scopolamine individually (Lin & Harnly, 2010). Moreover, the species demonstrate the repressive influence on tyrosinase and monoamine oxidases (MAO) with different potency of administered extracts (Chang et al., 2007). As an illustration, another analysis was performed to check the repressive action of the methanolic extract of C. indicum on the tyrosinase enzyme. The extract showed satisfactory results not only in the case of tyrosinase but also in induced anti-anxiety effects suggesting its anxiolytic potential (Hong et al., 2012). On the whole, chrysanthemum flower extracts have massive potential to deal with various neurological diseases (Shahrajabian et al., 2019).

Bambusa vulgaris

Bamboo is a fast-growing plant belonging to the Bambusoideae, a sub-family of the Poaceae family, and is found immensely in Asian regions (Wróblewska et al., 2018).

Albeit, the plant is utilized for various ornamental and construction purposes, some species are also recognized for their medicinal effects. For instance, leaves and shoots of Bambusa arundinacea and Phyllostachys edulis are popular for their use as dietary supplements and medicine particularly in the Traditional Chinese medicinal system. Bamboo leaves have a fairly large quantity of flavonoids and phenolic compounds such as vitexin and luteolin which are responsible for their anti-carcinogenic, diuretic, anti-inflammatory, and anti-oxidative characteristics (Jayarambabu et al., 2021).

An investigation conducted by Liu et al. (2016) to explore the potential of bamboo leaf extract exhibited its significant effect in ameliorating spatial cognition in dementia-induced test subjects (mice). The presumed mechanism for this purpose included its role in elevating acetylcholine levels and repressing the intrinsic efficacy of acetylcholinesterase in the brain (Horiuchi et al., 2003). Furthermore, treated mice demonstrated enhanced levels of dopamine and repressing the intrinsic efficacy of MAO-B, causing cognitive betterment. Bambo leaves are also a large reservoir of phenolic compounds that block the accumulation of melanin thus showing hormonal changes by blocking the tyrosinase activity (Seki et al., 2010). Choi et al., published promising results about his findings regarding IC50 value of ethyl acetate extract of bamboo leaves contrary to tyrosinase (Khatun et al., 2013). Also, the plant elicited an intense scavenging activity to lower the concentration of Reactive oxygen species (ROS). On the whole, additional research done to discover the hidden effects unique combination of phytoconstituents present in leaves regarding immunomodulation and cognitive repair and the results were very positive (Choi et al., 2018).

Ginkgo biloba

It has been on earth for over 300 million years and discovered for its medicinal potential since hundreds of years, *Ginkgo* (*G.*) *biloba* is such a hidden treasure that its whole list of phyto-contituents and their pharmacological properties are still part of latest research (de Souza et al., 2020). Albeit, a large variety of chemical extracts have been prepared from the plant and their therapeutic properties are explored in several lab investigations both in vivo and in vitro (Abdel-Salam et al., 2013). Many further studies were done to identify the neuroprotective effects of its two prominent chemical constituents named as ginkgolides and bilobalides alongside their mechanism of action (Shu et al., 2020). For example, in a research analysis done by Tchantchou et al. (2007) the widely used plants extract referred to as EGb 761 was investigated to unveil its incredible therapeutic properties in serious chronic diseases like diabetes, hepatic dysfunction, and several neurodegenerative ailments including cognitive damage and noteworthy neurobehavioral deficits like Huntington's disease (Tchantchou et al., 2007).

Studies elicited that phytosomes present in *G. biloba* can stimulate and enhance the antioxidative effect of enzymes in the brain regions of rats (Mahdy et al., 2011). Another study conducted on a similar extract to analyze its impact on Alzheimer's model depicted very promising effects by blocking the acetylcholinesterase and preventing the neurological cells against the toxic effects of amyloid-beta (Luo et al., 2002). These noteworthy effects were the result of its free radical scavenging activity, improved synaptic plasticity, and neurotransmitter release due to the presence of 6% terpenoids and almost 25% flavonoids in it. Another study was done to explore the neuroprotective potential of its major phytoconstituents i.e. bilobalide and ginkgolides (Sousa et al., 2010). Both these compounds demonstrated excellent anti-oxidant effects, improved cell viability, and ameliorated inflammatory neurons. However, bilobalide also blocked the cytokine release. Furthermore, when investigated in the Parkinson's disease models, *G. biloba* exhibited remarkable improvements by stimulating the expression of dopamine transporters (Kuang et al., 2018). It also affects the neurotransmitter systems, exhibiting the downregulation of GABA and repression of NMDA (Ivic et al., 2003). Moreover, compared to other traditional therapeutic plants, *G. biloba* also depicts anti-depressant effects by stimulating the brain to boost the uptake of ginsenosides (Liang et al., 2020). The findings indicate the multi-purpose functional capability of *G. biloba* in improving and retaining neurological health.

CONCLUSION

Many age-related neurological and hepatic ailments that influence millions of people throughout the world and for which there are no feasible treatments are rising simultaneously with the usual life expectancy. In the pharmaceutical industry, resources from the earth are highly critical to producing novel bioactive substances. Due to their antioxidant qualities and interactions with biological processes in the body, plants have demonstrated promise in preventing neurological and hepatic disorders as well as improving memory and cognitive abilities. Clinical studies must be employed to verify health claims and ensure safe, standardized extracts, according to health regulators. Additional investigation is required to resolve these limitations lately that despite extensive research on medicinal plants, there are still voids in our understanding of their chemistry, manufacturing processes, and dosages.

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