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Review Article

Natural Allies in Kidney Protection: A Comprehensive Review of Potential Nephroprotective Properties of Various Medicinal Plants

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ABSTRACT

Kidney ailments are a serious worldwide health concern, with high morbidity rates and a lack of effective treatment choices. Traditional nephroprotective drugs often just provide symptomatic relief and do not treat the underlying cellular damage. This circumstance emphasizes the importance of investigating other therapy options. In this context, herbal medications have gained popularity as possible nephroprotective agents. Their efficacy is due to a wide range of bioactive substances with therapeutic effects such as antioxidant, anti-inflammatory, and cytoprotective qualities. These characteristics indicate that herbal treatments may play an important role in the management and maintenance of kidney health, necessitating more research into their therapeutic potential. This article provides a thorough evaluation of several nephroprotective plants, concentrating on their phytochemical profiles, the molecular processes by which they function, and supporting experimental evidence. The plants being considered are *Boerhaavia diffusa*, *Curcuma longa*, *Phyllanthus niruri*, *Camellia sinensis*, *Withania somnifera*, and *Tribulus terrestris*. These species have significant promise for decreasing nephrotoxicity caused by drugs such as cisplatin and gentamicin, as well as oxidative stress. The review emphasizes that these plants work through a variety of pathways, including redox homeostasis regulation, inflammatory cytokine suppression, mitochondrial health preservation, and kidney histoarchitecture repair. Such findings highlight their therapeutic potential in nephroprotection. Herbal nephroprotectants have great potential as safe and useful supplements in the treatment of renal disorders, according to a summary of preclinical research. These results point to their possible contribution to improving renal treatment approaches. However, a number of translational gaps that presently impede their practical adoption must be addressed. The lack of thorough clinical validation, difficulties with the bioavailability of many herbal remedies, and the lack of defined dose regimens are important problems. To address these problems and provide a strong basis for the application of herbal

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nephroprotectants in clinical practice, thorough pharmacokinetic and molecular studies are needed.

INTRODUCTION

Kidney complications, particularly acute kidney injury (AKI) and chronic kidney disease (CKD), have emerged as major worldwide health issues in the twenty-first century.¹ The kidneys play an important role in metabolic homeostasis by managing fluid balance, maintaining electrolyte composition, controlling blood pressure, and aiding the excretion of metabolic waste.² These illnesses have a significant impact on global health systems, mandating increasing awareness and resources for prevention and treatment. Renal function disruptions can have serious effects, such as impaired kidney performance and multi-organ failure. Current worldwide epidemiological studies show that chronic kidney disease (CKD) affects around 10% of the global population, making it a hidden epidemic with major medical, social, and economic consequences.³ Diabetes, hypertension, dyslipidemia, recurrent infections, nephrotoxic medicines, and environmental toxins are the leading causes of renal impairment. Addressing these contributory variables is critical to controlling CKD and its effects on general health.

Renal damage is a complex interaction of interrelated processes at the cellular and molecular levels, including oxidative stress, inflammatory cascades, apoptotic cell death, fibrotic remodeling, and mitochondrial dysfunction.⁴ Reactive oxygen species (ROS) overproduction overwhelms antioxidant defenses, resulting in DNA damage, protein alteration, and lipid peroxidation. Activation of transcription factors like NF- κ B and the release of pro-inflammatory cytokines, including TNF- α , IL-1 β , and IL-6, play a crucial role in the development of inflammation and subsequent tissue damage within the kidneys.⁵

This inflammation leads to cellular infiltration and exacerbation of renal injuries. The impairment of mitochondrial function further enhances energy deficits in renal tubular cells, which accelerates processes such as apoptosis and fibrosis. Together, these pathological events contribute to the progression from mild renal dysfunction to more severe, irreversible kidney damage.⁶

Conventional nephroprotective treatments, such as N-acetylcysteine (NAC), corticosteroids, angiotensin-converting enzyme inhibitors (ACEIs), and angiotensin receptor blockers (ARBs), have only had little efficacy in slowing the course of renal disease.⁷ The success of these medicines is frequently inhibited by a number of issues, including unpleasant effects associated with long-term usage, narrow therapeutic windows that limit their applicability, high prices that may limit patient access, and low efficacy when faced with multifaceted renal insults. These problems underscore the critical need for the development of safer, more effective nephroprotective therapies capable of addressing numerous pathways implicated in renal damage, with the goal of improving patient outcomes in renal disease treatment.

Herbal and plant-based medications have received widespread attention for their broad pharmacological capabilities, synergistic phytoconstituents, and low toxicity levels. For many years, traditional medical systems such as Ayurveda, Siddha, Unani, and Traditional Chinese medical (TCM) have used nephroprotective herbs, retaining a vast compendium of ethnopharmacological information that contributes to modern scientific understanding.⁸ Notable plants in this context include *Boerhaavia diffusa*, *Phyllanthus niruri*, *Curcuma longa*, *Tribulus terrestris*, *Cynodon dactylon*, and *Withania somnifera*, which have traditionally been



recognized for their diuretic, antioxidant, anti-inflammatory, and rejuvenating effects on renal tissues.⁸

Herbal remedies for nephrology have shown encouraging results, but there are still a lot of unanswered questions that prevent their widespread use. Clinical validation, the pharmacokinetics of herbal treatments, possible drug interactions, extract standardization, dose optimization, and long-term safety assessments are important topics that require more research. By summarizing current information on the molecular processes, phytochemical profiles, and experimental results associated with nephroprotective medicinal plants, this review seeks to resolve these problems. The study aims to lay the groundwork for future studies that strive to determine the clinical efficacy of herbal medications in preserving kidney function by

highlighting both recent scientific achievements and the gaps in present research.

MATERIALS AND METHODS:

The review utilized a structured and systematic methodology for both literature collection and analysis. It identified pertinent studies through extensive searches conducted in several reputable scientific databases such as PubMed, Scopus, ScienceDirect, and Google Scholar. The search strategy implemented predefined keywords alongside Boolean operators and inclusion/exclusion criteria, which aimed to guarantee the retrieval of high-quality, peer-reviewed research. Subsequently, all selected articles underwent a thorough screening process, critical evaluation, and synthesis to achieve a rigorous and impartial assessment of the available evidence.

Table: A Complete List of Plants That Have Been Shown to Protect the Kidneys, Along With the Extracts Used, the Main Phytochemicals, the Study Models, the Mechanistic Insights, and the Supporting Literature.

SL. NO	Common name	Scientific name	Extract	Key compounds	Models Primary Suggested	Mechanisms	References
1	Turmeric	<i>Curcuma longa</i>	Ethanollic	Curcumin (diarylheptanoid), volatile oil	Cisplatin, gentamicin, I/R, diabetic rats	Antioxidant, anti-inflammatory, anti-apoptotic, antifibrotic.	9
2	Neem	<i>Azadirachta indica</i>	Aqueous / ethanolic	Limonoids, flavonoids, azadirachtin	Gentamicin, cisplatin models	Antioxidant, anti-inflammatory, anti-oxidative enzyme upregulation.	10
3	Chanca piedra	<i>Phyllanthus niruri</i>	Methanolic / aqueous	Lignans, flavonoids, tannins	Gentamicin, glycerol, STZ models	Antioxidant, diuretic/anti-urolithic, membrane stabilization.	11
4	Punarnava	<i>Boerhavia diffusa</i>	Aqueous / hydroalcoholic	Alkaloids, flavonoids, rotenoids	Gentamicin, cisplatin, diabetic rats	Diuretic, anti-inflammatory, antioxidant, anti-fibrotic.	12
5	Ashwagandha	<i>Withania somnifera</i>	Ethanollic / aqueous	Withanolides (steroidal lactones)	Diabetic nephropathy, toxic models	Antioxidant, immunomodulatory, anti-apoptotic.	13
6	Indian Barberry	<i>Berberis asiatica</i> / <i>B. vulgaris</i>	Ethanollic / aqueous	Berberine (isoquinoline alkaloid)	STZ-diabetic, gentamicin	Antihyperglycemic, antioxidant, anti-inflammatory.	14
7	Green tea	<i>Camellia sinensis</i>	Aqueous / ethanolic	Catechins (EGCG), polyphenols	Cisplatin, gentamicin, I/R	Antioxidant, anti-inflammatory, chelation of ROS.	15
8	Garlic	<i>Allium sativum</i>	Aqueous / ethanolic / oil	Allicin, organosulfur compounds	Cisplatin, gentamicin	Antioxidant, improves renal hemodynamics, anti-inflammatory.	16
9	Ginger	<i>Zingiber officinale</i>	Aqueous / ethanolic	Gingerols, shogaols	Gentamicin, cisplatin	Antioxidant, anti-inflammatory, anti-apoptotic.	16

SL. NO	Common name	Scientific name	Extract	Key compounds	Models Primary Suggested	Mechanisms	References
10	Licorice	<i>Glycyrrhiza glabra</i>	Aqueous / ethanolic	Glycyrrhizin, flavonoids	Gentamicin, nephrotoxicity models	Antioxidant, anti-inflammatory, mineralocorticoid modulation.	17
11	Arjuna	<i>Terminalia arjuna</i>	Hydroalcoholic / aqueous	Tannins, flavonoids, triterpenoids	Experimental nephrotoxicity	Antioxidant, anti-inflammatory, improves renal markers.	18
12	Amla	<i>Emblica officinalis</i> (<i>Phyllanthus emblica</i>)	Aqueous / ethanolic	Ascorbic acid, tannins (emblicanin)	Diabetic nephropathy models	Antioxidant, antiglycation, anti-inflammatory.	19
13	Guduchi	<i>Tinospora cordifolia</i>	Aqueous / ethanolic	Alkaloids, diterpenoids	Gentamicin, cisplatin models	Antioxidant, immunomodulatory, anti-inflammatory.	20
14	Holy basil	<i>Ocimum sanctum</i> / <i>O. tenuiflorum</i>	Aqueous / ethanolic	Eugenol, ursolic acid, flavonoids	Gentamicin, I/R	Antioxidant, anti-inflammatory, anti-apoptotic.	21
15	Aloe vera	<i>Aloe vera</i>	Aqueous gel / hydroalcoholic	Anthraquinones, polysaccharides	Gentamicin, cisplatin	Antioxidant, anti-inflammatory, membrane stabilization.	22
16	Tribulus	<i>Tribulus terrestris</i>	Aqueous / ethanolic	Steroidal saponins, flavonoids	Gentamicin, diabetic models	Antioxidant, anti-inflammatory, diuretic effects.	23
17	Solanum nigrum	<i>Solanum nigrum</i>	Aqueous / methanolic	Steroidal alkaloids, flavonoids	Gentamicin, paracetamol nephrotoxicity	Antioxidant, anti-inflammatory, cytoprotective.	24
18	Silymarin	<i>Silybum marianum</i>	Silymarin extract	Silybin (flavonolignan)	Cisplatin, gentamicin	Antioxidant, stabilizes cell membranes, anti-fibrotic.	25
19	Neem leaf	<i>Moringa oleifera</i>	Aqueous / ethanolic	Flavonoids, glucosinolates	Gentamicin, STZ models	Antioxidant, restores antioxidant enzymes, anti-inflammatory.	26
20	Fenugreek	<i>Trigonella foenum-graecum</i>	Aqueous / ethanolic	Alkaloids, saponins, flavonoids	Diabetic nephropathy	Hypoglycemic, antioxidant, anti-inflammatory.	27

SL. NO	Common name	Scientific name	Extract	Key compounds	Models Primary Suggested	Mechanisms	References
21	Cassia	<i>Cassia fistula</i>	Ethanollic / aqueous	Anthraquinones , flavonoids	Gentamicin, cisplatin	Antioxidant, anti-inflammatory.	28
22	Centella	<i>Centella asiatica</i>	Aqueous / ethanolic	Triterpenoids (asiaticoside)	Toxic nephropathy models	Antioxidant, anti-inflammatory, collagen modulation.	29
23	Karela	<i>Momordica charantia</i>	Aqueous / ethanolic	Charantin, polypeptide-P	Diabetic nephropathy (STZ)	Antihyperglycemic, antioxidant, anti-inflammatory.	30
24	Holy Basil	<i>Rauwolfia serpentina</i>	Ethanolic	Reserpine (alkaloid)	Historically tested in renal models	Vasomodulatory, antioxidant (used cautiously).	31
25	Garlic chive	<i>Allium cepa</i>	Aqueous / ethanolic	Quercetin, organosulfur compounds	Gentamicin, cisplatin	Antioxidant, anti-inflammatory.	32
26	Houttuynia	<i>Houttuynia cordata</i>	Aqueous / ethanolic	Flavonoids, volatile oils	Nephrotoxic models	Anti-inflammatory, antioxidant.	33
27	Ginkgo	<i>Ginkgo biloba</i>	Ethanolic / standardized extract	Ginkgolides, flavonoids	Cisplatin nephrotoxicity	Antioxidant, microcirculation improvement.	34
28	Gynostemma	<i>Gynostemma pentaphyllum</i>	Aqueous / ethanolic	Saponins (gypenosides)	Diabetic nephropathy models	Antioxidant, antifibrotic, AMPK modulation.	35
29	Andrographis	<i>Andrographis paniculata</i>	Ethanolic / aqueous	Andrographolide (diterpene lactone)	Nephrotoxicity models	Anti-inflammatory, antioxidant.	36
30	Saffron	<i>Crocus sativus</i>	Aqueous / ethanolic	Crocin, safranal	Cisplatin, gentamicin	Antioxidant, anti-apoptotic, anti-inflammatory.	37
31	Moringa	<i>Moringa oleifera</i>	Aqueous / ethanolic	Flavonoids, glucosinolates	Gentamicin, diabetic models	Antioxidant, anti-inflammatory.	38
32	Rosemary	<i>Rosmarinus officinalis</i>	Ethanolic / aqueous	Rosmarinic acid, carnosic acid	Experimental toxic nephropathy	Antioxidant, anti-inflammatory.	39
33	Cinnamon	<i>Cinnamomum verum</i>	Ethanolic / aqueous	Cinnamaldehyde, polyphenols	Diabetic nephropathy	Antiglycation, antioxidant, anti-inflammatory.	40
34	Euphorbia	<i>Euphorbia hirta</i>	Aqueous / ethanolic	Flavonoids, polyphenols	Experimental renal injury	Antioxidant, anti-inflammatory.	41

SL. NO	Common name	Scientific name	Extract	Key compounds	Models Primary Suggested	Mechanisms	References
35	Achyranthes	<i>Achyranthes aspera</i>	Hydroalcoholic	Saponins, flavonoids	Nephrotoxicity models	Antioxidant, membrane protective.	42
36	Gymnema	<i>Gymnema sylvestre</i>	Aqueous / ethanolic	Gymnemic acids (triterpenoids)	Diabetic nephropathy models	Antihyperglycemic, antioxidant.	43
37	Piper longum	<i>Piper longum</i>	Ethanolic / aqueous	Piperine (alkaloid)	Nephrotoxicity models	Bioavailability enhancer, antioxidant, anti-inflammatory.	44
38	Bacopa	<i>Bacopa monnieri</i>	Ethanolic / aqueous	Bacosides (saponins)	Toxicity models	Antioxidant, anti-inflammatory, neuro/reno-protective effects.	45
39	Grape seed extract	<i>Vitis vinifera</i>	Ethanolic	Proanthocyanidins (polyphenols)	Cisplatin, gentamicin	Strong antioxidant, anti-inflammatory.	46
40	Pumpkin seeds	<i>Cucurbita pepo</i>	Aqueous / oil	Sterols, fatty acids	Toxicity models	Antioxidant, diuretic properties.	47
41	Sweet potato leaf	<i>Ipomoea batatas</i>	Aqueous	Anthocyanins, phenolics	Diabetic nephropathy	Antioxidant, metabolic modulation.	48
42	Bael	<i>Aegle marmelos</i>	Aqueous / ethanolic	Coumarins, alkaloids	Toxic nephropathy models	Antioxidant, anti-inflammatory.	49
43	Neem	<i>Azadirachta indica</i>	Aqueous	Limonoids	Experimental kidney injury	Antioxidant, anti-inflammatory.	50
44	Baical skullcap	<i>Scutellaria baicalensis</i>	Ethanolic	Baicalin (flavone glycoside)	Cisplatin, nephrotoxicity models	Antioxidant, anti-inflammatory, anti-apoptotic.	51
45	Radish	<i>Raphanus sativus</i>	Aqueous / ethanolic	Glucosinolates, polyphenols	Toxicity models	Antioxidant, diuretic.	52
46	Black seed	<i>Nigella sativa</i>	Aqueous / oil	Thymoquinone (quinone)	Cisplatin, gentamicin, I/R	Antioxidant, anti-inflammatory, anti-apoptotic.	53
47	Pomegranate	<i>Punica granatum</i>	Aqueous / ethanolic	Punicalagins, ellagitannins	Gentamicin, cisplatin, diabetic models	Antioxidant, anti-inflammatory	54

CONCLUSION:

The current analysis indicates that herbal medicinal plants can successfully cure breast cancer, making them a cost-effective option for underdeveloped countries. It could be feasible to find anti-cancer compounds by studying traditional medicinal plants in order to create new drugs and comprehend the origins of cancer. This might lead to the development of stronger drugs and improved healthcare for underdeveloped countries.

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