Review Article

Tunisian Nephroprotective Plants: A Review

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Abstract

In Tunisian folk medicine, several herbs are prescribed for reducing renal damage and to avoid kidney related complications. These can be of immense value in combating renal damage. In this review, we provide a description of the current literature on the use of indigenous herbs as alternative medicine for treating renal damage. The aim of this review was to collect information on promising active phytoconstituents such as organosulfur compounds, polyphenols, terpenes, alkaloids phenylpropanoids, and polysaccharides from Tunisian plants that have been scientifically examined for their nephroprotective capacities. Twenty-nine Tunisian medicinal plants have been reported for their significant nephroprotective activities against renal toxicities in animal models. Lamiaceae was the most commonly used Tunisian plant family used for renal protection. The leaves were maximally used for nephroprotection compared to the other plant parts. Nephroprotective agents, such as those found in medicinal plants, have protective and curative capacities against nephrotoxicity (Fig. 1). Co-administration of various medicinal plants possessing nephroprotective activity along with different nephrotoxic factors, including drugs and industrial chemicals. This literature review highlights the use of some medicinal plants as nephroprotective agents. To defend against this nephrotoxicity, some medicinal plants, known as nephroprotective agents, have been highlighted in this review.

Introduction

The kidneys are vital organs that have several physiological functions. Their principle role is to maintain homeostasis of body fluids by filtering and secreting metabolites and minerals from the blood and excreting the nitrogenous waste along with water, as urine. The kidneys also help to regulate blood pressure, glucose metabolism, and erythropoiesis. The kidneys filter about 180 liters of blood daily, about four times the quantity traversing any other organ. Consequently, the kidneys are highly exposed to toxins in the blood and are susceptible to tissue damage. Kidney disease is the ninth leading cause of death, and patients with kidney disease have significant morbidity and mortality.

The number of patients presenting with kidney disorders is increasing at an alarming rate. Currently, there are approximately over one million people worldwide who require dialysis or a functioning graft. Kidney replacement has been the only therapy for end stage of renal failure, and dialysis has remained the only alternative when a kidney transplant is not possible.

Nephrotoxicity is one of the most common kidney problems induced by drugs or toxins. A number of potent therapeutic drugs, including aminoglycoside antibiotics, chemotherapeutic agents and chemical reagents (ethylene glycol, carbon tetrachloride, and sodium oxalate), and heavy metals (lead, mercury, cadmium, and arsenic), can adversely affect the kidney resulting in acute renal failure. In addition to drugs, other factors can lead to acute renal failure, such as age, diabetes, hypertension, liver disease, and oliguria. Nephroprotective agents, such as those found in medicinal plants, have protective and curative capacities against nephrotoxicity (Fig. 1). Co-administration of various medicinal plants possessing nephroprotective activity along with different nephrotoxic agents may attenuate toxicity. Previously, Tunisian medicinal plants have been used to treat diabetes, ulcer, cancer, liver, and coronavirus illnesses. In this review, we highlighted the current literature focused on Tunisian nephroprotective plants.

We searched the PubMed, Scientific Information Database, Sco...
pus, Web of Science, Science Direct, Google and Google scholar databases for primary literature using the keywords nephroprotective effect, kidneys, nephrotoxicity, renal failure, medicinal plants, and Tunisia. A total of 175 researches was included in this work. The different experimental nephroprotective researches allowed describing 29 Tunisian medicinal plants for their significant nephroprotective activities against renal toxicities in animal models (Table 1). These toxicities were made by several toxins belonging to drugs, industrial additives and pesticides (Table 2).

**Allium sativum**

*Allium sativum* belongs to the family of Alliaceae, popularly known as garlic. It has reported anti-atherosclerotic, cardioprotective, neuroprotective, antihyperlipidemic, antidiabetic, anti-hypertension, antistress, anticancer, antiviral, antibacterial, antifungal, anti-oxidant, and dermatologic properties. Neir et al. determined that the nephroprotective potential of the methanol extract from *A. sativum* cloves (20 mg/kg body weight (BW) against deltamethrin (7.2 mg/kg BW) caused oxidative damage in rat kidneys. Deltamethrin treatment increased kidney conjugated dienes and lipid peroxidase (LPO) levels. However, catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (GPx) levels were decreased. Garlic administration regulated these changes provoked by deltamethrin. Allicin is one of the major bioactive components of garlic constituted from the stable precursor allicin by the enzyme action alliinase when garlic cloves are crushed or macerated. García Trejo et al. determined that allicin had beneficial effects in chronic kidney disease compared to Losartan.

**Artemisia arborescens**

*Artemisia arborescens* is a perennial evergreen woody shrub belonging to the family of Asteraceae. *A. arborescens* is a widely used traditional medicine that possesses ethnomedical and biologic benefits. The protective effect of *A. arborescens* was mainly attributed to the presence of phenolic acids and flavonoids. *A. arborescens* extract was found to optimize many parameters of oestrogenic toxicity. The protective effect of *A. arborescens* leaves (200 mg/kg BW) was studied against oestrogen-induced toxicity. The beneficial effects of the aqueous ethanol extract from *A. arborescens* leaves (200 mg/kg BW) was studied against oestrogenic toxicity. The beneficial effects of the aqueous ethanol extract from *A. arborescens* leaves (200 mg/kg BW) was studied against oestrogenic toxicity.
Table 1. Tunisian medicinal plants with nephroprotective activity

<table>
<thead>
<tr>
<th>Scientific plant name</th>
<th>Part used*</th>
<th>Extract</th>
<th>Bioactive compounds</th>
<th>Nephrotoxin used</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allium sativum</td>
<td>Cloves</td>
<td>Methanol</td>
<td>Organosulfur compound (allicin)</td>
<td>Deltamethrin</td>
<td>13</td>
</tr>
<tr>
<td>Artemisia arborescens</td>
<td>Leaves</td>
<td>Aqueous ethanol</td>
<td>Phenolic compounds (vanillic acid, coumarin, rutin, luteolin, naringenin and quercetin)</td>
<td>Estradiol + progesterone</td>
<td>14</td>
</tr>
<tr>
<td>Artemisia campestris</td>
<td>Aerial parts</td>
<td>Essential oil</td>
<td>Terpenes (β-pinene, p-cymene and α-pinene)</td>
<td>Deltamethrin</td>
<td>15</td>
</tr>
<tr>
<td>Ceratonia siliqua</td>
<td>Leaves</td>
<td>Methanol</td>
<td>Phenolic compounds (rutin, resveratrol, coumarin, luteolin and epicatechin)</td>
<td>Cisplatin</td>
<td>17</td>
</tr>
<tr>
<td>Capparis spinosa</td>
<td>Leaves</td>
<td>Ethyl acetate</td>
<td>Phenolic compounds (syringic acid, myricetin glycosides and gallic acid derivatives)</td>
<td>CCl4</td>
<td>18</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Scientific plant name</th>
<th>Part used*</th>
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<th>Bioactive compounds</th>
<th>Nephrotoxin used</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Citrus limon</em></td>
<td>Leaves</td>
<td>Essential oil</td>
<td>Terpene (limonene)</td>
<td>Aspirin</td>
<td>19</td>
</tr>
<tr>
<td><em>Eryngium maritimum</em></td>
<td>Seeds</td>
<td>Methanol</td>
<td>Phenolic compounds (caffeic acid, protocatechuic acid, gallic acid, luteolin and kaempferol)</td>
<td>Cisplatin</td>
<td>20</td>
</tr>
<tr>
<td><em>Eucalyptus globulus</em></td>
<td>Leaves</td>
<td>Aqueous</td>
<td>Phenolic compounds (rutin, ellagic acid, chlorogenic acid, and quercetin 3-glucuronide)</td>
<td>Acetaminophen</td>
<td>21</td>
</tr>
<tr>
<td><em>Euphorbia bivonae</em></td>
<td>Leaves</td>
<td>Methanol</td>
<td>Monosaccharides (saccharose, arabinose, inositol, glucose, pyranose, trehalose and fructose)</td>
<td>Hydrogen peroxide</td>
<td>22</td>
</tr>
<tr>
<td><em>Globularia alypum</em></td>
<td>Leaves</td>
<td>Methanol</td>
<td>Phenolic compound (globularin)</td>
<td>Deltamethrin</td>
<td>23</td>
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</table>

(continued)
Table 1. (continued)

<table>
<thead>
<tr>
<th>Scientific plant name</th>
<th>Part used*</th>
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</tr>
</thead>
<tbody>
<tr>
<td><em>Hammada scoparia</em></td>
<td>Leaves</td>
<td>Methanol</td>
<td>Alkaloids (carnegine and N-methylisosalsoline) and flavonoids (isorhamnetin triglycerides)</td>
<td>Ethanol</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hyparrhenia hirta</em></td>
<td>Aerial parts</td>
<td>Methanol</td>
<td>Flavonoid compounds (apigenin, quercetin and luteolin)</td>
<td>Sodium nitrate</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lavandula stoechas</em></td>
<td>Aerial parts</td>
<td>Essential oil</td>
<td>Terpenes (tricyclene, cymene, Δ-Cadinene and Selina-3,7(11)-diene)</td>
<td>Malathion</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lycium europaeum</em></td>
<td>Leaves</td>
<td>Methanol</td>
<td>Phenolic compounds (cisplatin, caffeic acid, gallic acid, naringenin, epicatechin, vanillic acid, rutin and p-coumaric acid) Polysaccharide</td>
<td>CCl4</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cisplatin</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Flowers</td>
<td>Aqueous</td>
<td>Phenolic compounds (gallic acid, p-coumaric acid, rutin, kaempferol, quercetin and luteolin)</td>
<td>Vanadium</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Leaves</td>
<td>Methanol</td>
<td></td>
<td>Lithium carbonate</td>
<td>30</td>
</tr>
</tbody>
</table>

*References:*
24 - [Reference](#)
25 - [Reference](#)
26 - [Reference](#)
27 - [Reference](#)
28 - [Reference](#)
29 - [Reference](#)
30 - [Reference](#)

(continued)
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<thead>
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<th>Bioactive compounds</th>
<th>Nephrotoxin used</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentha piperita</td>
<td>Leaves</td>
<td>Essential oil</td>
<td>Terpenes (menthol and iso-menthone)</td>
<td>CCl4</td>
<td>31</td>
</tr>
<tr>
<td>Morus alba</td>
<td>Leaves</td>
<td>Aqueous acetone</td>
<td>Phenolic compounds (chlorogenic acid and its derivatives)</td>
<td>Glyphosate</td>
<td>32</td>
</tr>
<tr>
<td>Nitraria retusa</td>
<td>Fruits</td>
<td>Aqueous</td>
<td>Phenolic compounds (chlorogenic acid, p-coumaric acid, caffeic acid, gallic acid and kaempferol)</td>
<td>Penconazole</td>
<td>33</td>
</tr>
<tr>
<td>Olea europea</td>
<td>Fruits</td>
<td>Oil</td>
<td>Phenolic compounds (oleuropein and hydroxytyrosol)</td>
<td>Acrylamide</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Leaves</td>
<td>Aqueous</td>
<td></td>
<td>Deltamethrin</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Fruits</td>
<td>Ethanol</td>
<td></td>
<td>Bisphenol A</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Diclofenac</td>
<td></td>
</tr>
<tr>
<td>Opuntia ficus-indica</td>
<td>Cladodes</td>
<td>Aqueous</td>
<td>Phenolic compounds quercetin, vanillic acid, gallic acid, rutin, kaempferol, catechin, epicatechin, coumarin, isorhamnetin and caffeic acid)</td>
<td>Lithium carbonate</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sodium dichromate</td>
<td>39</td>
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(continued)
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</tr>
</thead>
<tbody>
<tr>
<td><em>Periploca angustifolia</em></td>
<td>Leaves</td>
<td>Monosaccharides (saccharose, trehalose, L-inositol and M-inositol)</td>
<td>Cadmium</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td><em>Phoenix dactylifera</em></td>
<td>Fruits</td>
<td>Aqueous</td>
<td>Phenolic acids (ferulic, caffeic and p-coumaric acids)</td>
<td>Dichloroacetic acid</td>
<td>41</td>
</tr>
<tr>
<td><em>Pinus halepensis</em></td>
<td>Needles</td>
<td>Essential oil</td>
<td>Terpenes (Z-β-caryophyllene, β-myrcene and α-pinene)</td>
<td>Aspirin</td>
<td>42</td>
</tr>
<tr>
<td><em>Rhus tripartitum</em></td>
<td>Fruits</td>
<td>Methanol</td>
<td>Phenolic acid (betulinic acid)</td>
<td>Cisplatin</td>
<td>43</td>
</tr>
<tr>
<td><em>Rosmarinus officinalis</em></td>
<td>Leaves</td>
<td>Aqueous</td>
<td>Phenolic compounds (carnosic and rosmarinic acids)</td>
<td>CCl4</td>
<td>44</td>
</tr>
</tbody>
</table>
the potent nephroprotective effect of vanillic acid, coumarin, rutin, and luteolin was determined against cisplatin-induced nephrotoxicity in rats. Additionally, the renal protective potential of naringenin and quercetin was studied in cadmium-induced oxidative renal dysfunction in rats.

**Artemisia campestris**

*Artemisia campestris* is a perennial herb belonging to the family of Asteraceae. *A. campestris* has many medicinal actions including anthelmintic, antidiabetic, anticancer, antimicrobial, antifungal, antihypertensive, emmenagogue, and antivenom. It has been also used to treat cutaneous, genital, digestive, and respiratory disorders. Saoudi *et al.* investigated the protective effects of *A. campestris* essential oil against deltamethrin nephrotoxicity in rats. Deltamethrin toxicity caused a significant increase in creatinine, urea, and uric acid levels, and a decrease in LPO, SOD, CAT and GPx. However, *A. campestris* essential oil reduced the deltamethrin-induced alterations in serum levels, lipid peroxidation, and oxidative stress. The protective effect of *A. campestris* essential oil could be attributed to its anti-oxidant potential. Similar results were obtained by Saoudi *et al.* who determined the protective effect of *A. campestris* essential oil against chlorpyrifos-induced kidney injury in rats. Akrout *et al.* found that *A. campestris* essential oil was dominated by β-pinene, p-cymene, and α-pinene. In fact, Başar reported that pinenes in volatile oils derived from plants are used widely to treat renal stone disease.

<table>
<thead>
<tr>
<th>Scientific plant name</th>
<th>Part used*</th>
<th>Extract</th>
<th>Bioactive compounds</th>
<th>Nephrotoxin used</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Salvia officinalis</em></td>
<td>Aerial parts</td>
<td>Essential oil</td>
<td>Terpenes (β-caryophyllene, limonene and carvacrol)</td>
<td>Vanadium</td>
<td>45</td>
</tr>
<tr>
<td><em>Teucrium polium</em></td>
<td>Aerial parts</td>
<td>Aqueous</td>
<td>phenylpropanoid glycosides (verbascoside and poliumoside), flavones (apigenin and its derivatives) and two methoxyflavones</td>
<td>CCI4</td>
<td>46</td>
</tr>
<tr>
<td><em>Trigonella foenum-graecum</em></td>
<td>Seeds Powder</td>
<td>Flavonoid glycosides (vicenin-2, isoschaftoside and isoorientin)</td>
<td>Aluminum chloride</td>
<td>47 48</td>
<td></td>
</tr>
<tr>
<td><em>Vitis vinifera</em></td>
<td>Seeds/Skin Fruits</td>
<td>Ethanol Powder</td>
<td>Phenolic compounds (2,5-dihydroxybenzoic acid gallic acid, and vanillin)</td>
<td>Doxorubicin Oxidative stress</td>
<td>49 50</td>
</tr>
</tbody>
</table>

*Sientific plant names were followed by references*
**Capparis spinosa**

_Capparis spinosa_ is a spontaneous xerophyte plant belonging to the Capparaceae family, widely found in the Mediterranean. _C. spinosa_ is popularly used as a condiment and medicinal plant. It is used in traditional medicine to treat diseases such as gastrointestinal problems, hypertension, anemia, rheumatism, and diabetes. It is also an analgesic, anti-arthritic, antihemorrhoidal, anticancer, anti-inflammatory, depurative, diuretic, emmenagogue, and anti-oxidant.

The nephroprotective action of the methanolic _C. spinosa_ (200 mg/kg in olive oil) was determined against cisplatin-provoked (13 mg/kg in olive oil) kidney injury in rats. Pre-treatment with the methanolic extract of _C. spinosa_ leaves 7 days before cisplatin exposure and daily thereafter significantly reduced plasma levels of creatinine, urea, and uric acid, reduced malondialdehyde (MDA) levels, and reduced antioxidant enzyme activity of SOD, CAT, and GPx in the kidney and reversed the kidney damage. The leaf of this plant is rich in rutin, resveratrol, coumarin, epicatechin, and luteolin, all of which have been shown to demonstrate protection against cisplatin-induced nephrotoxicity in rats, as reported by Radwan and Fattah for rutin, Valentovic et al. for resveratrol, Sen et al. for coumarin, Tanabe et al. for epicatechin, and Domitrović et al. for luteolin.

**Ceratonia siliqua**

_Ceratonia siliqua_ is a slow-growth ever-green tree belonging to the Leguminosae family, cultivated for years in the Mediterranean region. _C. siliqua_ fruits, brown pods 10–25 cm in length, have traditionally been used as animal and human food. The seed is mainly used for gum extraction. _C. siliqua_ pods, bark, and leaves have been used in Tunisian folk medicine as a laxative, diuretic, antidiarrheal, and to treat gastroenteritis of lactating babies.

Animals receiving the ethyl acetate extract of _C. siliqua_ leaves (250 mg/kg BW) daily by intraperitoneal injection for 8 days followed by a single dose of CCl4 (1 ml/kg in olive oil) using an intragastric tube after 24 hours of the last dose showed increased levels of urea, creatinine, and LPO with a concomitant decrease in SOD, CAT, and GPx in the kidney. Pretreatment with ethyl acetate extract of _C. siliqua_ leaves had a potent nephroprotective effect in accordance with histopathological observations. The leaf extract of this

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**Table 2. Effect of Tunisian medicinal plants on different nephrotoxins**

<table>
<thead>
<tr>
<th>Nephrotoxicity factors</th>
<th>Model nephrotoxin used</th>
<th>Scientific plant name*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides</td>
<td>Deltamethrin</td>
<td><em>Allium sativum</em> 13; <em>Artemisia campestris</em> 15; <em>Globularia alypum</em> 23; <em>Olea europea</em> 35</td>
</tr>
<tr>
<td></td>
<td>Chlorpyrifos</td>
<td><em>Artemisia campestris</em> 16</td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td><em>Lavandula stoechas</em> 26</td>
</tr>
<tr>
<td></td>
<td>Glyphosate</td>
<td><em>Morus alba</em> 32</td>
</tr>
<tr>
<td></td>
<td>Penconazole</td>
<td><em>Nitraria retusa</em> 33</td>
</tr>
<tr>
<td></td>
<td>Acrylamide</td>
<td><em>Olea europea</em> 34</td>
</tr>
<tr>
<td></td>
<td>CCl4</td>
<td><em>Ceratonia siliqua</em> 18; <em>Lycium europaeum</em> 27; <em>Mentha peperita</em> 31; <em>Rosmarinus officinalis</em> 44; <em>Teucrium polium</em> 46; <em>Trigonella foenum-graecum</em> 48</td>
</tr>
<tr>
<td>Industrial additives</td>
<td>Bisphenol A</td>
<td><em>Olea europea</em> 36</td>
</tr>
<tr>
<td></td>
<td>Hydrogen peroxide</td>
<td><em>Euphorbia bivona</em> 22</td>
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<td>Cadmium Sodium</td>
<td><em>Periplaca angustifolia</em> 40</td>
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<td></td>
<td>dichromate</td>
<td><em>Opuntia ficus-indica</em> 39</td>
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<td></td>
<td>Sodium nitrate</td>
<td><em>Hyparrhenia hirta</em> 75</td>
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<tr>
<td></td>
<td>Vanadium</td>
<td><em>Malva sylvestris</em> 25; <em>Salvia officinalis</em> 45</td>
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<tr>
<td>Drugs</td>
<td>Dichloroacetic acid</td>
<td><em>Phoenix dactylifera</em> 41</td>
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<td></td>
<td>Doxorubicin</td>
<td><em>Vitis vinifera</em> 49</td>
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<td>Acetomophen</td>
<td><em>Eucalyptus globules</em> 21</td>
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<td></td>
<td>Aluminum chloride</td>
<td><em>Trigonella foenum-graecum</em> 47</td>
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<tr>
<td></td>
<td>Aspirin</td>
<td><em>Citrus limon</em> 51; <em>Pinus halepensis</em> 42</td>
</tr>
<tr>
<td></td>
<td>Cisplatin</td>
<td><em>Capparis spinosa</em> 17; <em>Eryngium maritimum</em> 20; <em>Lycium europaeum</em> 28; <em>Rhus tripartitum</em> 43</td>
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<td></td>
<td>Diclofenac</td>
<td><em>Olea europea</em> 37</td>
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<td>Estradiol</td>
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<tr>
<td></td>
<td>Progesterone</td>
<td><em>Artemisia arborescens</em> 14</td>
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</tbody>
</table>
plant mainly contains syringic acid, myricetin glycosides, and gallic acid derivatives. Sancak et al. noted the potent protective effect of syringic acid on kidney ischemia-reperfusion injury. The beneficial effect of myricetin on renal function was reported by Ozcan et al. and Asici et al. determined the beneficial impact of gallic acid against methotrexate-induced kidney injury in rats.

Citrus limon

Citrus limon is a medicinal plant of the family Rutaceae found in Tunisia and other Mediterranean countries (Egypt, Italy, Spain and Turkey). C. limon has been used in folk medicine to treat obesity, diabetes, high lipid, cardiovascular diseases, brain disorders, and some cancer types. C. limon leaf essential oil (1 ml/kg) was evaluated for its nephroprotective effect against a high dose of aspirin-induced acute kidney damage (600 mg/kg) in rats. C. limon essential oil protected against aspirin, showing a decrease in thiobarbituric acid reactive substances (TBARS) and an increase of aspirin-induced acute kidney damage (600 mg/kg) in rats. The pro-protective effect of syringic acid on kidney ischemia-reperfusion injury. The protective effect of methanol extract from G. alypum leaves (400 mg/kg in corn oil) against the nephrotoxicity induced by a chronic exposure to deltamethrin (4 mg/kg in corn oil) has been studied in rats. Deltamethrin administration provoked kidney damage, and treatment with G. alypum leaf extract restored plasma creatinine, urea, and uric acid levels and reduced the elevated MDA and PC levels. G. alypum leaf extract has been shown to restore renal activity in accordance with histopathological observations owing to its bioactive compounds. G. alypum leaf extract is rich mainly in globularin (60.31%). Merghache et al. isolated this phenolic compound and determined its antidiabetic and antilipidemic capacities in normal and streptozotocin-induced diabetic rats.

Euphorbia bivonae

Euphorbia bivonae is an herbaceous plant belonging to the Euphorbiaceae family and is widespread in the coastal areas of the Mediterranean basin. E. bivonae has several biological properties, including antiproliferative, anti-oxidant, nephroprotective, and hepatoprotective effects. Athmouni et al. evaluated the preventive action of E. bivonae leaf polysaccharides against hydrogen peroxide (H₂O₂)-induced toxicity in human embryonic kidney (HEK293) cells. Results revealed that H₂O₂-exposure induced a significant increase in intracellular reactive oxygen species and lipid peroxidation in HEK293 cells. However, E. bivonae polysaccharide pretreated cells (100 μg/mL) significantly enhanced cell viability following H₂O₂ exposure. Polysaccharide analysis showed the richness of E. bivonae in seven monosaccharides: saccharose, arabinose, inositol, glucose, pyranose, trehalose, and fructose.

Globularia alubum

Globularia alubum is a perennial shrub plant belonging to the Globulariaceae family, widely distributed in the Mediterranean area and largely used for its therapeutic virtues. G. alubum species are known for their medicinal properties. G. alubum is commonly used as a hypoglycaemic, laxative, cholagogue, stomachic, and purgative agent, as well as in the treatment of renal disease. The protective effect of methanol extract from G. alypum leaves (400 mg/kg in corn oil) against the nephrotoxicity induced by a chronic exposure to deltamethrin (4 mg/kg in corn oil) has been studied in rats. Deltamethrin administration provoked kidney damage, and treatment with G. alypum leaf extract restored renal activity in accordance with histopathological observations owing to its bioactive compounds. G. alypum leaf extract is rich mainly in globularin (60.31%). Merghache et al. isolated this phenolic compound and determined its antidiabetic and antilipidemic capacities in normal and streptozotocin-induced diabetic rats.

Hammada scoparia

Hammada scoparia is a small highly-branched halophytic shrub belonging to the Chenopodiaceae family. It is widely used in North African traditional medicine to prevent several diseases such as cancer, hepatitis, inflammation, and obesity. The methanol extract of H. scoparia leaves (200 mg/kg/day) was evaluated for its renoprotective effect against ethanol-induced (4 g/kg) renal dysfunction in rats. H. scoparia extract attenuated the increase of TBARS in kidneys, and enhanced the anti-oxidant status of rats by increasing the levels of SOD, CAT, and GPx. The overexpression of glycogen synthase kinase–3β and proline–rich tyrosine kinase 2 in kidneys of ethanol–treated rats was normalized after H. scoparia extract treatment. H. scoparia leaf extract is rich in alkaloids (carnegine and N-methylisosalsoline) and flavonoids (isorhamnetin triglycerides), as reported by Bourouga et al. and Ben Salah et al. Qi et al. determined the potential renoprotective effects of isorhamnetin in a type 2 diabetic rat model.
**Hyparrhenia hirta**

*Hyparrhenia hirta* is a perennial grass belonging to the Poaceae family. It is native to the southern Africa and Mediterranean regions. It is used in traditional medicine for its diuretic properties. Bouaziz et al. studied the nephroprotective effect of methanolic extract from *H. hirta* aerial parts (200 mg/kg in corn oil) against sodium nitrate-induced kidney (400 mg/kg in corn oil) dysfunction. Sodium nitrate-mediated oxidative stress in kidneys is characterized by enhanced lipid peroxidation and reduced CAT, SOD, and GPX activity. Renal damage was histologically characterized by degeneration of renal tubule cells and mononuclear cell infiltration. A reversal of anti-oxidant enzymes and peroxidative damage in kidneys by *H. hirta* extract has been attributed to its anti-oxidant and anti-peroxidative properties and its role as a scavenger of free radicals, which could be due to its flavonoid content, namely apigenin, quercetin, and luteolin derivatives. The potent nephroprotective effect of apigenin, quercetin, and luteolin was determined against cisplatin-induced nephrotoxicity in rats.

**Lavandula stoechas**

*Lavandula stoechas* is a medicinal plant belonging to the Lamiaceae family. Selmi et al. investigated the nephroprotective activity of *L. stoechas* aerial part essential oil (10, 30, and 50 mg/kg) against malathion-induced (200 mg/kg) oxidative stress in mice. Malathion treatment decreased body weight and perturbated metabolic parameters. However, *L. stoechas* essential oil abolished all malathion-induced body gain loss and kidney relative weight. Furthermore, pretreatment with *L. stoechas* essential oil at 40 mg/kg prior to CCl4 significantly reduced stress parameters (urea and creatinine). A significant reduction in kidney lipid peroxidation (TBARS) and an increase in anti-oxidant enzymes (SOD, CAT, and GPX) were also observed after treatment with *L. stoechas* leaf essential oil at 15 and 40 mg/kg prior to CCl4 significantly reduced stress parameters (urea and creatinine). A significant reduction in kidney lipid peroxidation (TBARS) and an increase in anti-oxidant enzymes (SOD, CAT, and GPX) were also observed after treatment with *M. peperita* leaf essential oil at 40 mg/kg markedly ameliorated the histopathological hepatic and kidney lesions induced by CCl4. *M. peperita* leaf essential oil contains active ingredients including menthol and iso-menthone. These two compounds exhibit a potent anti-inflammatory activity, indicating that *M. peperita* leaf essential oil could be a promising new product against CCl4-induced oxidative damage in the kidney, consistent with that reported by Bellassoued et al.

**Mentha peperita**

*Mentha peperita* is a native genus of the Mediterranean region belonging to the Lamiaceae family. It is widely used in food and in traditional medicine. Bellassoued et al. investigated *M. peperita* leaf essential oil for its nephroprotective action against CCl4-induced renal failure in rats. *M. peperita* leaf essential oil was orally administrated for 7 consecutive days (5, 15, 40 mg/kg BW) to rats prior to CCl4 (1 ml/kg BW) intraperitoneal treatment. Results showed that pretreatment with *M. peperita* leaf essential oil at 15 and 40 mg/kg prior to CCl4 significantly reduced stress parameters (urea and creatinine). A significant reduction in kidney lipid peroxidation (TBARS) and an increase in anti-oxidant enzymes (SOD, CAT, and GPX) were also observed after treatment with *M. peperita* leaf essential oil (40 mg/kg) compared to CCl4-treated rats. Furthermore, pretreatment with *M. peperita* leaf essential oil at 40 mg/kg markedly ameliorated the histopathological hepatic and kidney lesions induced by CCl4. *M. peperita* leaf essential oil contains active ingredients including menthol and iso-menthone. These two compounds exhibit a potent anti-inflammatory activity, indicating that *M. peperita* leaf essential oil could be a promising new product against CCl4-induced oxidative damage in the kidney, consistent with that reported by Bellassoued et al.

**Morus alba**

The leaves of *M. alba* of the Moraceae family, commonly known as mulberry, are mainly used as food for silk worms and are sometimes used as cattle fodder in different parts of the world. The infusion and decoction of leaves have been used to prevent or treat urinary disorders. The aqueous aceton extract of *M. alba* leaves (100 mg/kg) was studied against glyphosate-induced (100 mg/kg) kidney injury in mice. Renal oxidative stress induced by glyphosate was evidenced by an increase in MDA and protein carbonyl levels and a decline in SOD activity. *M. alba* leaf extract appeared to modulate these altered biochemical parameters by maintaining free iron and Ca2+ homeostasis, as well as regulate en-
The aqueous extract from \textit{O. ficus-indica} cladodes on kidney injury induced by sodium dichromate.\textsuperscript{39} As reported by Saad \textit{et al.}\textsuperscript{38} the aqueous extract from \textit{O. ficus-indica} cladodes was characterized by the presence of quercetin, vanillic acid, gallic acid, rutin, kaempferol, catechin, epicatechin, coumarin, isorhamnetin, and caffeic acid. All of these phenolic compounds have been well studied for their potent nephroprotection, particularly quercetin.\textsuperscript{41} Vanillic acid, gallic acid,\textsuperscript{41} rutin,\textsuperscript{41} kaempferol,\textsuperscript{41} catechin,\textsuperscript{41} isorhamnetin,\textsuperscript{41} and caffeic acid.\textsuperscript{41}

\textbf{Nitraria retusa}

\textit{Nitraria retusa} belongs to the Nitrariaceae family and is used for its anti-inflammatory properties\textsuperscript{124} and to facilitate healing.\textsuperscript{125} In this study, the nephroprotective effect of aqueous extract from \textit{N. retusa} fruit (300 mg/kg BW) against penceonazole (67 mg/kg BW) caused kidney injury.\textsuperscript{33} \textit{N. retusa} treatment provoked a significant decrease in the levels of MDA, \textit{H}_2\textit{O}_2, protein carbonyl and advanced oxidation protein products, as well as improved alkaline phosphatase (ALP) and gamma glutamyltranspeptidase activities. Polyphenol constituents of \textit{N. retusa} fruit aqueous extract could enhance their anti-oxidant activities in nephroprotection. \textit{N. retusa} fruit extract mainly contains hydroxycaffeic acid, epicatechin derivatives, \textit{p}-coumaric acid, cyanidin derivative, 3-O-methylgallic acid, taxifolin, chlorogenic acid, and kaempferol derivative. Among these phenolics, chlorogenic acid,\textsuperscript{65} \textit{p}-coumaric acid,\textsuperscript{119} caffeic acid,\textsuperscript{80} gallic acid,\textsuperscript{118} and kaempferol\textsuperscript{41} are known for their potent nephroprotection.

\textbf{Olea europea}

\textit{Olea europea} is a known olive tree belonging to the Oleaceae family. It represents a great economic and social importance owing mainly to the great value of olive oil. This olive oil is the primary source of fat in the Mediterranean diet, which has been associated with low mortality related to cardiovascular disease.\textsuperscript{126} Ghorbel \textit{et al.}\textsuperscript{34} found that extra vierge olive oil abrogated acrylamide-induced nephrotoxicity. Ethanolic extract from \textit{O. europea} fruit (200 mg/kg BW) and its phenolic compound, oleuropein (50 mg/kg BW), has been shown to protect against nephrotoxicity caused by deltamethrin (15 mg/kg bw) in rats.\textsuperscript{35} Deltamethrin administration can increase MDA levels and reduce SOD and CAT activities. \textit{O. europea} fruit and oleuropein have been used as treatments for inflammation and apoptosis. Oleuropein, verbascoside, luteolin-7-glucoside, apigenin-7-glucoside, and hydroxytyrosol are the main components of the ethanolic extract from \textit{O. europea} fruit.\textsuperscript{36} The nephroprotective effect of oleuropein and hydroxytyrosol extracted from Tunisian olive leaf extract have been investigated in rats treated with bisphenol A.\textsuperscript{36} In recent study, Soussi \textit{et al.}\textsuperscript{37} found that the aqueous extract of Tunisian \textit{O. europaea} leaves protected against kidney damage induced by diethlene in mice.

\textbf{Opuntia ficus-indica}

\textit{Opuntia ficus-indica} is a plant popularly known as prickly pear belonging to the Cactaceae family. It is widely distributed in the Mediterranean area, Mexico, and South Africa, and is widely known because of its nutritional and medicinal usage.\textsuperscript{127} Administration of lithium carbonate (25 mg/kg BW) has been shown to cause a significant increase in serum creatinine, uric acid, and urea levels. Additionally, a significant decrease in SOD, CAT, and GPx activities was associated with a significant increase in MDA levels. However, treatment with \textit{O. ficus indica} extract (100 mg/kg BW) prevented these alterations and maintained the anti-oxidant status in rats. Histopathological observations support this biochemical evidence of nephroprotection.\textsuperscript{38} Similar results were obtained for the aqueous extract from \textit{O. ficus-indica} cladodes on kidney injury induced by sodium dichromate.\textsuperscript{39} As reported by Saad \textit{et al.}\textsuperscript{38} the aqueous extract from \textit{O. ficus-indica} cladodes was characterized by the presence of quercetin, vanillic acid, gallic acid, rutin, kaempferol, catechin, epicatechin, coumarin, isorhamnetin, and caffeic acid. All of these phenolic compounds have been well studied for their potent nephroprotection, particularly quercetin.\textsuperscript{41} Vanillic acid, gallic acid,\textsuperscript{41} rutin,\textsuperscript{41} kaempferol,\textsuperscript{41} catechin,\textsuperscript{41} isorhamnetin,\textsuperscript{41} and caffeic acid.\textsuperscript{41}

\textbf{Periploca angustifolia}

\textit{Periploca angustifolia} evergreen shrub is a member of the Apocynaceae family. It is found wild in North Africa (from Morocco to Egypt), southern Spain, Sicily, Malta, Crete, Lebanon, and Syria. \textit{P. angustifolia} is used in traditional medicine for diabetes, rheumatism, hemorrhoids, and gastric ulcer.\textsuperscript{125} The preventative action of polysaccharides isolated from \textit{P. angustifolia} leaves against cadmium-caused oxidative stress in kidneys of rats has been tested. Results indicated that cadmium treatment increased the levels of urea and creatinine in the serum. The increased levels of protein oxidation and lipid peroxidation along with decreased activities of SOD, CAT and GPx were ameliorated by \textit{P. angustifolia} polysaccharides pre-treatment. Histopathological studies also supported the prevention action of \textit{P. angustifolia} polysaccharides. Saccharose is the major monosaccharide component of \textit{P. angustifolia} leaves, followed by trehalose, L-inositol, and M-inositol, as reported by Athmouni \textit{et al.}\textsuperscript{50}

\textbf{Phoenix dactylifera}

\textit{Phoenix dactylifera} is a tree commonly known as date palm belonging to the Arecaceae family. \textit{P. dactylifera} is mostly cultivated for the consumption of its fruit, which has been utilized since ancient times as an important staple food and in ethnomedicine in different parts of the world.\textsuperscript{130} The fruit of \textit{P. dactylifera} is used as a digestive and astringent for intestinal ailments, treatment for sore throat, colds, bronchial asthma, to relieve fever, cystitis, gonorrhea, edema, liver and abdominal ailments, and to counteract alcohol intoxication.\textsuperscript{131} Dichloroacetic acid administration (2 g/l) caused augmentation of renal MDA levels and significant diminution of GSH levels. Moreover, dichloroacetic acid altered the anti-oxidant enzyme activities and deteriorated renal function, as assessed by increased plasma urea, uric acid, and creatinine levels. Treatment with \textit{P. dactylifera} extract (4 ml/kg) significantly normalized the plasma levels of creatinine, urea, and uric acid, reduced the MDA levels, significantly normalized anti-oxidant enzyme activities and GSH levels, and restored the kidney histology in rats.\textsuperscript{41} Therefore, it has been speculated that \textit{P. dactylifera} extract protects rats from kidney damage through its anti-oxidant capacity attributed to make-up of phenolic acids, mainly ferulic, caffeic, and \textit{p}-coumaric acids.\textsuperscript{41} In fact, ferulic,\textsuperscript{32} caffeic,\textsuperscript{38} and \textit{p}-coumaric\textsuperscript{119} acids are known for their efficient nephroprotective action.

\textbf{Pinus halepensis}

\textit{Pinus halepensis} is a tree belonging to the Pinaceae family found around the Mediterranean basin. The resin and decoction of all Pinus species have antiseptic, diuretic, rubefacient, vermifuge, antidiabetic, and cicatrisant properties.\textsuperscript{133} Bouzenna \textit{et al.}\textsuperscript{42} studied the protective effect of essential oil from \textit{P. halepensis} needles
on aspirin-induced acute kidney damage in rats. Rats were orally treated with \textit{P. halepensis} essential oil (1 ml/kg) for 56 days and then given aspirin (600 mg/kg) orally thrice a day at an interval of 4 h for 4 successive days. Results showed that aspirin induced an increase in serum biochemical parameters as well as oxidative stress in kidney. There was an increase in TBARS and a decrease in SOD, CAT, and GPx in kidney. Administration of \textit{P. halepensis} essential oil corrected these parameters. Hamrouni \textit{et al.} \cite{134} found that the essential oil of Tunisian \textit{P. halepensis} needles was characterized by the predominance of monoterpenic hydrocarbons, mainly \textit{\-}caryophyllene, \textit{\-}myrcene and \textit{\-}pinene. These volatile compounds could interact to protect against aspirin-induced nephrotoxicity.

\textbf{Rhus tripartitum}

\textit{Rhus tripartitum} is a dioecious shrub belonging to the Anacardiaceae family.\cite{135} \textit{R. tripartitum} is widely used to treat many diseases such as diarrhea and dysentery, colitis, gastrointestinal diseases, inflammatory diseases, diabetes, haemoptysis, conjunctivitis, animal bites and poisons, hemorrhoids, sexual disease, fever, pain, and various cancers. Tilihi \textit{et al.} \cite{43} investigated the protective action of methanolic extract from \textit{R. tripartitum} fruit (200 mg/kg in olive oil) against cisplatin-induced (13 mg/kg) nephrotoxicity in rats. The increased levels of biochemical parameters (creatinine, urea, and uric acid) were attenuated by pretreatment with \textit{R. tripartitum} fruit extract. Histopathologic observation showed that pre-treatment with \textit{R. tripartitum} fruit extract restored the pathology. These results could be due to the richness of \textit{R. tripartitum} fruit extract in phenolics, especially betulinic acid. In fact, the efficient renoprotective effects of betulinic acid isolated from \textit{R. tripartitum} fruit extract were restored the pathology.

\textbf{Rosmarinus officinalis}

\textit{Rosmarinus officinalis}, commonly known as rosemary is a perennial, aromatic medicinal plant belonging to the Lamiaceae family. It is shrub-shaped with branches full of leaves, exuding a characteristic fragrance.\cite{137} One study evaluates the effects of aqueous extract from \textit{R. officinalis} leaves against kidney toxicity induced by \textit{CCl4} in mice. Results showed that the renal damage induced by \textit{CCl4} was associated with a rise in oxidative stress, an increase of TBARS, and changes the nephropathology parameters including creatinine, blood urea nitrogen, and urea. However, a decrease in GSH levels and anti-oxidant enzymes (SOD, CAT, and GPx) was observed. These findings were substantiated by histological analysis. Pretreatment with \textit{R. officinalis} leaf extract attenuated \textit{CCl4}-related toxic effects.\cite{44} The polyphenolic profile of Tunisian \textit{R. officinalis} leaf extract is characterized by its richness in carnosic and rosmarinic acids.\cite{138} The potent nephroprotective effects of carnosic\cite{139} and rosmarinic\cite{140} acids were observed in cisplatin-induced nephrotoxicity in rats.

\textbf{Salvia officinalis}

\textit{Salvia officinalis}, popularly known as sage, is a member of the Lamiaceae family. It is an aromatic plant widely distributed in the world. Since ancient times, \textit{S. officinalis} has been an ingredient in perfumes, a flavoring in a variety of food preparations,\cite{141} and a medicinal plant used to fight fever, rheumatism, perspiration, sexual malfunction, chronic bronchitis, and various mental diseases.\cite{142} Koubaa \textit{et al.} \cite{45} evaluated the impact of the essential oil from \textit{S. officinalis} aerial parts (15 mg/kgBW) on renal nephrotoxicity induced by vanadium (5 mg/kg BW) in rats. A marked increase in LPO and PCO levels with a significant decrease in SOD, CAT, and GPx. However, the administration of \textit{S. officinalis} essential oil significantly restored these biochemical markers and pathological lesions. This protective effect seems to be due to the richness of \textit{S. officinalis} essential oil in \textit{\-}caryophyllene, limonene, carvacrol, caryophyllene, borneol, \textit{\-}pinene, and \textit{\-}thujene, as reported by Koubaa \textit{et al.}.\cite{45} Horváth \textit{et al.} \cite{143} found that \textit{\-}caryophyllene ameliorated cisplatin-induced nephrotoxicity. Rehman \textit{et al.} \cite{45} reported the protective role of limonene against renal damage induced by the anticancer drug doxorubicin. The protective effect of carvacrol on renal function in gentamicin-induced nephrotoxicity in rats was determined by Ahmadvand \textit{et al.} \cite{144}.

\textbf{Teucrium polium}

\textit{Teucrium polium} is defined as golden germander belonging to the Lamiaceae family. It has been used to treat abdominal pain, indigestion, and diabetes. The aqueous extract of \textit{T. polium} aerial parts (5 g/l) was investigated against \textit{CCl4}-induced (0.5 ml/kg) nephrotoxicity in rats. \textit{CCl4} treatment increase serum renal markers (urea and creatinine) and lipid peroxidation and decreased anti-oxidant enzymes (SOD, CAT and GPx). However, pretreatment with \textit{T. polium} extract protected against oxidative damage and biochemical changes induced by \textit{CCl4}, which were validated by histopathological observations.\cite{46} According to Goulas \textit{et al.} \cite{145} \textit{T. polium} aerial part extract is characterized by the presence of phenylpropanoid glycosides (verbascoside and poliuloside), flavones (apigenin and its derivatives), and two methoxyflavones, with poliuloside being the most abundant and active component of \textit{T. polium} extract.

\textbf{Trigonella foenum-graecum}

\textit{Trigonella foenum-graecum} is an annual herb popularly known as fenugreek that belongs to the Leguminosae family. It is native to an area extending from Iran to northern India and widely cultivated in China, India, Egypt, Ethiopia, Morocco, Ukraine, Greece, and Turkey.\cite{146} It is an ancient traditional medicinal plant due to its olfactory, antifever, anti-inflammatory, antimicrobial, anticancer, antidiabetic, antihyperglycemic, laxative, galactogogue, and digestive effects. Belalid-Nouira \textit{et al.} \cite{47} evaluated fenugreek seeds (5% in the diet) for their effects on rat nephrotoxicity caused by aluminum chloride (500 mg/kg BW for one month then 1,600 ppm via drinking water). Aluminum chloride inhibited ALP, decreased total antioxidant status, and an induced LPO in the blood and brain. Treatment with fenugreek seed powder helped to restore normal plasma values of urea, creatinine, ALP, and glucose, as well as increased the total antioxidant status, inhibited LPO, and alleviated histopathological changes in the injured kidney. Belghith-Hadrich \textit{et al.} \cite{148} also determined the potent renoprotective action of fenugreek seeds on renal oxidative stress and nephropathy caused by a high cholesterol diet in rats. Mbariki \textit{et al.} \cite{48} noted that fenugreek seed supplementation protected the kidney from \textit{CCl4}-induced oxidative stress and toxicity in rats. According to Belalid-Nouira \textit{et al.} \cite{47} Belghith-Hadrich \textit{et al.} \cite{148} and Mbariki \textit{et al.} \cite{48} the anti-oxidant activity of fenugreek seeds could be attributed to polyphenols, particularly flavonoids. Three flavonoid glycosides were detected in methanol extract from the fenugreek seed extract: vicenin-2, isoschaftoside, and isoorientin.\cite{149}
Vitis vinifera

Vitis vinifera is a perennial, woody climbing grapevine belonging to the Vitaceae family. It is indigenous to southern Europe and western Asia and is cultivated today in all temperature regions of the world. 159 Grape seeds contain 6–20% oil, used for edible purposes, soaps, and as a linseed substitute. A malagama made from the seed is a folk remedy for condylomata of the joints. Leaves astringent and cooling, sweet, laxative, stomachic, has been used in thirst, body heat, coughs, hoarseness, consumption, and wasting diseases. The fruit, prepared in various manners, is said to be a remedy for mola, uterine tumors, and hardness of the liver, tumors, and cancer.159 Mokni et al. 49 evaluated the protective effect of the ethanol extract from V. vinifera seeds and skin against doxorubicin-induced renal toxicity in rats. Animals were treated with the ethanol extract from V. vinifera seeds and skin for 8 days and administered doxorubicin (20 mg/kg) 4 days later. Results showed that doxorubicin induced renal toxicity by affecting the renal architecture and plasma creatinine. Doxorubicin also induced oxidative stress characterized by an increase in MDA, calcium, and H2O2 and a decrease in CAT and SOD. Unexpectedly, doxorubicin increased peroxidase and decreased carbonyl protein and plasma urea. Treatment with V. vinifera extract counteracted almost all adverse effects induced by doxorubicin. Turkı et al. 50 conducted an investigation of supplementation with grape seed extract capsules (2 g GSE/day) or placebo on chronic kidney disease patients for 6 months. Grape seed ameliorated inflammation by decreasing C-reactive protein and triglyceridemia and counteracted anemia and thrombocytopenia. Grape seed extract is a polyphenolic mixture exhibiting anti-oxidant and anti-inflammatory properties as reported by Turkı et al. 50 According to Mokni et al. 49 the main compound of grape seed and skin extracts are 2,5-dihydroxybenzoic acid, gallic acid, and vanillin. Among these phenolic compounds, gallic acid 118 and vanillin 152 have been well studied for their potent nephroprotection.

Future directions

Research on Tunisian nephroprotective plants has been mainly done in a laboratory setting with a limited number of animals. Thus, additional studies must be done with a greater number of experiments, different animal models, and human subjects. It should be mentioned that this is the first review that summarizes several reports on Tunisian nephroprotective plants. The literature demonstrates that these plants contain bioactive compounds that could be used to treat kidney disease. This review may be valuable to health professionals, scientists, and scholars working in the field of pharmacology and therapeutics to produce new safety drug formulations to treat kidney diseases.

Conclusions

In this review, 29 Tunisian medicinal plants were summarized for their significant nephroprotective activities against renal toxicities in animal models. Lamium family was the most commonly used nephroprotective Tunisian plant. Leaves were maximally used for nephroprotection compared to the other plant parts. In the case of Indian nephroprotective plants, Asif 153 also reported that the leaves were most frequently used in the treatment of nephrotoxicity, with the most dominant family being Euphorbiaceae. In this review, most studies focused on drug-induced renal failure, which is a major challenge in medical practice. Other studies focused on other important nephrotoxicity factors, including industrial chemicals, particularly CCl4-induce nephrotoxicity. In general, CCl4 enhanced levels of renal markers (urea and creatinine) in the serum of experimental animals. It also increased oxidative stress markers resulting in increased LPO with a concomitant decrease in SOD, CAT, and GPX in the kidney. To protect against this nephrotoxicity, some medicinal plants, have curative properties attributed to various complex chemical substances as organosulfur compounds, polyphenols, polysaccharides, phenylpropanoids, terpenes, and alkaloids.

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Conflict of interest

The authors declare no conflicts of interest.

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