Phytochemicals analysis and antioxidant potential of hydroalcoholic extracts of fresh fruits of *Pistacia atlantica* and *Pistacia khinjuk*

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**Abstract**

Medicinal plants are known for containing potent antioxidants, primarily due to the presence of phytochemical components with diverse biological properties. In this study, we assessed the chemical constituents and antioxidant potential of *Pistacia atlantica* and *Pistacia khinjuk*. The essential oils from *P. atlantica* and *P. khinjuk* oleoresin were obtained through hydrodistillation, and their chemical constituents were identified using gas chromatography-mass spectrometry (GC-MS). Additionally, we evaluated the total phenolic and flavonoid contents, total antioxidant activity, and free radical quenching potentials of hydroalcoholic extracts from *P. atlantica* and *P. khinjuk*. These assessments were performed using the Folin-Ciocalteu method, aluminum chloride method, phosphomolybdate test, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) inhibition assay (Half-maximal inhibitory concentration (IC₅₀ value)), respectively. The results revealed that the major phytochemical components in *P. atlantica* essential oil were α-pinene, camphene, β-pinene, D-limonene, cyclohexene, and careen. Additionally, *P. khinjuk* essential oil contained α-pinene, β-Pinene, trans-verbenol, bicyclo(3.1.1)heptan, verbene, camphene, D-limonene, and α-campholenal. Furthermore, the total phenols and flavonoids content of *P. atlantica* were higher than those of *P. khinjuk*. However, the total antioxidant capacity was significantly greater in *P. khinjuk* than in *P. atlantica*. The IC₅₀ value (DPPH assay) was also significantly higher in *P. khinjuk* compared to *P. atlantica*. Although the essential oils of both plants exhibited antioxidant effects, *P. atlantica* essential oils demonstrated superior antioxidant effects compared to *P. khinjuk*. In conclusion, the presence of abundant phytochemical components, such as monoterpens, was observed in both the plants. These findings suggest that *P. atlantica* and *P. khinjuk* generally possess considerable antioxidant activity.

**Keywords**

Antioxidant activity; chemical composition; GC-MS analysis; *Pistacia atlantica*; *P. khinjuk*

**Introduction**

In recent years, herbal medicines have gained popularity due to their therapeutic properties (1). Throughout the history of medicine, medicinal plants have consistently played a crucial role in treating various diseases, includ-
ing cardiovascular, gastrointestinal inflammatory, and neurodegenerative diseases (2). According to the World Health Organization (WHO), up to 80% of people worldwide now rely on traditional medicine for their primary health needs (3). The growing interest in scientific research has heightened the importance of medicinal plants and their phytochemical constituents for therapeutic and pharmaceutical purposes. Over the past few decades, numerous studies have aimed to explore various biological aspects of medicinal plants (4, 5). Over the years, considerable research attention has focused on exploring the antioxidant actions of medicinal herbs. A substantial body of evidence supports the notion that the antioxidant capacity of medicinal plants can counteract mechanisms associated with various diseases, particularly oxidative stress (6). The available data underscores the significance of oxidative stress in the pathophysiology of several pathological conditions. Oxidative stress occurs when the generation of free radicals, especially reactive oxygen species (ROS), surpasses the intrinsic antioxidant defense mechanism (7). Substances that quench ROS are recognized as antioxidants (3). Medicinal plants have been identified as potential sources of potent antioxidant compounds (3). Numerous studies have proposed that phytochemical constituents, such as flavonoids, polyphenols, saponins, tannins, and alkaloids, may play a potential role as antioxidants (3, 8).

The therapeutic benefits of medicinal plants have gained increasing importance in recent times, supported by data from numerous studies highlighting the medicinal and nutritional value of plant species belonging to the genus Pistacia (9, 10). Pistacia atlantica is among the well-known medicinal plants of this genus with various traditional uses attributed to it, including therapeutic actions on the gastrointestinal, nervous, cardiovascular, respiratory, and renal systems (10). Previous research has documented a range of beneficial effects of P. atlantica, including antioxidant, antimicrobial, anti-inflammatory, anticancer, antibacterial, and wound healing effects (9, 10). Several valuable compounds, such as phenolic compounds, flavonoids, and tannins, have been identified in various parts of P. atlantica (9). Another important species within the genus Pistacia is P. khinjuk (11). Research has shown that P. khinjuk has therapeutic applications in cardiovascular diseases, toothache, indigestion, and cancers, as per traditional medicine (11). While a considerable body of research has focused on the therapeutic effects of plant species belonging to the genus Pistacia, less attention has been given to the connection between these therapeutic impacts and the presence of phyto-constituents. Several studies have demonstrated the antioxidant (12), antibacterial, wound healing (13), and antihyperlipidemic (14) effects of P. khinjuk. Detailed phytochemical analysis of P. khinjuk revealed an abundance of phenols, tannins, and glycosides (15). Hence, this study was undertaken to examine the phytochemical constituents and antioxidant potential of P. atlantica and P. khinjuk.

The present study employed an in vitro approach to investigate the phytochemical constituents and antioxidant potential of Pistacia atlantica and P. khinjuk.

Chemicals and Reagents
All required chemicals including ethanol, sodium sulfate, sodium carbonate, Folin–Ciocalteu reagent, aluminium chloride, Tris, 2,2-Diphenyl-1-picrylhydrazyl (DPPH) and methanol, were purchased from Merck (Germany) and Sigma (USA) companies.

Plant Material Collection
For the purpose of this study, oleoresin and fruits of P. atlantica and P. khinjuk were collected in May 2020 from the Khargūshān Mountains, located at the end of the Khorraramabad-Andimesh freeway, and the Bisim Mountains in Khorraramabad County, Lorestan Province, Iran. Subsequently, the identification of the herbal samples was conducted by botanists from the Lorestan Agriculture and Natural Resources Research Center, Khorrarambad, Iran.

Essential Oil Preparation
After herbal identification, oleoresin samples were used for the preparation of essential oil. The essential oil was prepared according to the method of Bagheri et al. (16). Subsequently, the excess moisture in the essential oil was removed by placing it in a dark vial in a freezer at 18°C using anhydrous sodium sulfate.

Preparation of Extracts
To prepare hydroalcoholic extracts of P. khinjuk and P. atlantica, fresh fruits were air-dried under shaded conditions at room temperature. The dried fruits were subsequently ground into a powder. The resulting powders were dissolved in a hydro-alcoholic mixture comprising 50% distilled water and 50% ethanol, with a ratio of 1:1, at a temperature of 70°C. The maceration method was employed to extract hydroalcoholic solutions from P. atlantica and P. khinjuk. The suspension was allowed to macerate at 30°C for a duration of 72 hr. After maceration, the suspension was filtered, and the solvent was separated using a rotary evaporator (IKA-RV10, Germany) (17).

Phytochemical Analysis by Gas Chromatography/Mass Spectroscopy (GC-MS)
A GC-17A gas chromatograph (Shimadzu, Japan) coupled to a gas chromatography/mass spectroscopy (GC/MS) QP5050 mass spectrometer (Shimadzu, Japan) was used to identify the phytochemical components. A 30 m, 0.22 mm ID fused silica capillary column was utilized to separate the chemical compounds. In addition, a 0.25 µm film of BP-5 (Shimadzu, Japan) was applied to the column. The carrier gas used was helium at 0.8 mL/min. The split injection was carried out with a split ratio of 1:50. The detector temperature was 260°C and the injection port temperature was 280°C. The GC column temperature was increased to 280°C and then held for 5 min. The essential oil constituents were characterized by calculating the retention indices under temperature-programmed conditions for n-alkanes (C8-C20). The oil was also analyzed on a PB-5 column under the same chromatographic conditions (16).
Total Phenols Content

The content of total phenolic compounds in the extracts was determined using the Folin-Ciocalteu method. Each tube was filled with 750 μL of the Folin–Ciocalteu reagent. Subsequently, 100 μL of the extracts were added to each tube, followed by vortexing, and the mixture was maintained at 25°C for 5 min. Next, 750 μL of sodium carbonate were added to the tubes, and the solutions were kept at 25°C for 40 min. The absorbance was measured at 725 nm, and a standard curve was plotted. The results were expressed as milligrams of gallic acid equivalent per 100 grams (mg GAE /100 g) of dry extract.

Total Flavonoids Content

The total flavonoid content was determined through aluminum chloride colorimetric analysis. Initially, a 2% solution of aluminum chloride in ethanol was prepared. Subsequently, 500 μL of the aluminum chloride solution and 0.5 mL of each extract at various concentrations were added to individual tubes. After vortexing, the samples were left at 25°C for 1 hr. Absorbance measurements were taken at a wavelength of 420 nm, and standard curves for flavonoids were generated using quercetin. The results were expressed as milligrams of quercetin equivalent per 100 grams (mg QE/100 g) of dry extract.

Total Antioxidant Capacity

The total antioxidant capacity was determined using the phosphomolybdate method. Each tube was filled with 1 mL of phosphomolybdate reagent and 0.1 mL of the extract. The resulting solutions were vortexed and placed in boiling water for 90 min. Absorbance measurements were taken at a wavelength of 695 nm, and an antioxidant standard curve was constructed using ascorbic acid. The results were expressed as the equivalent of ascorbic acid per gram (AAE/g) of dry extract.

DPPH Assay

To evaluate the antioxidant effect of the extracts, the inhibition of free radical generation was measured using the DPPH method. Each tube was filled with 0.8 mL of buffer, 0.2 mL of extracts, and 1 mL of DPPH solution in methanol, followed by vortexing. The solutions were then incubated at 25°C in the dark for 45 min. After the designated time, the absorbance of the samples was measured at a wavelength of 517 nm. The absorbance values of both the blank and the samples were calculated using the following equation:

\[ I\% = \left( \frac{A_{\text{blank}} - A_{\text{sample}}}{A_{\text{blank}}} \right) \times 100 \]  

(Eqn. 1)

\( I\% \) = the percentage of DPPH scavenging effect  
\( A_{\text{blank}} \) = absorbance in negative control  
\( A_{\text{sample}} \) = absorbance of samples.

The results were reported as IC_{50} values to compare the scavenging effect of the extracts. The IC_{50} value represents the concentration of the specimens required to quench the free radicals of DPPH by 50% (18).

Statistical Analysis

Data analysis was conducted using SPSS version 22.0 and Microsoft Office Excel 2019. Tests were repeated three times for each sample, and means were computed. Analysis of Variance (ANOVA), followed by Duncan’s post hoc test, was employed to evaluate differences between experimental groups (extracts). Statistical significance was considered for all P values < 0.05.

Results

Chemical Constituents of Essential Oils

The chemical constituents of Pistacia atlantica and P. khinjuk were determined using GC–MS. The hydrodistillation of P. atlantica and P. khinjuk oleoresins yielded 26% and 23% of gum weight, respectively. As illustrated in Table 3 and Fig. 4, the essential oil of P. atlantica was found to contain six chemical constituents including α-pinene (93.2%), β-Pinene (2.55%), camphene (2.18%), cyclohexene (0.88%), D-limonene (0.82%), and careen (0.54%). The GC–MS analysis of the essential oil of P. khinjuk revealed eight phytochemical constituents, with α-pinene (78.71%), β-Pinene (11.73%), trans-verbnonl (3.18%), bicyclo(3.1.1.) heptan (1.86%), verbene (1.22%), camphene (1.2%), D-limonene (1.14%), and α-campholenal (1.06%) were found in P. khinjuk essential oil (Table 2 and Fig. 2).

Total Phenol Contents

Table 3 and Fig. 3 illustrates the total phenolic values of the hydroalcoholic extracts of P. atlantica and P. khinjuk. According to the results obtained, the total phenol content was 723.3750±102.49957 mg GAE /100 g dry extract for the hydroalcoholic extract of P. khinjuk, and 689.6250±87.73104 mg GAE /100 g dried extract for the hydroalcoholic extracts of P. atlantica. A significant difference in total flavonoid content was observed between P. atlantica and P. khinjuk (P = 0.6935).

Total Flavonoid Content

As depicted in Table 3 and Fig. 4, the total flavonoid content was 5.0485±0.60374 mg QE/100 g dry extract for the hydroalcoholic extract of P. atlantica and 4.2379±0.14854 mg QE/100 g dry extract for the hydroalcoholic extract of P. khinjuk, respectively. A significant difference in total flavonoid content was observed between P. atlantica and P. khinjuk (P = 0.0396).

Total Antioxidant Capacity

As Table 3 and Fig. 5 show, the total antioxidant capacity was 0.2427±0.06296 μmol AAE/100 g dry extract for the hydroalcoholic extract of P. atlantica and 0.7943±0.13071 μmol AAE/100 g dry extract for the hydroalcoholic extract of P. khinjuk, respectively. A significant difference in total flavonoid content was found between P. atlantica and P. khinjuk (P <0.0001).

DPPH Assay

The data in Table 3 indicates that the IC_{50} of the DPPH assay was 872.94 μg/mL for P. atlantica and 1094.14 μg/mL for P. khinjuk, respectively.
Table 1. Phytochemical constituents of *P. atlantica* essential oil.

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Peak number</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-pinene (terpene)</td>
<td>1</td>
<td>93.2</td>
</tr>
<tr>
<td>β-Pinene (monoterpene)</td>
<td>2</td>
<td>2.55</td>
</tr>
<tr>
<td>Camphene (monoterpene)</td>
<td>3</td>
<td>2.18</td>
</tr>
<tr>
<td>cyclohexene</td>
<td>4</td>
<td>0.88</td>
</tr>
<tr>
<td>D-limonene (monoterpene)</td>
<td>5</td>
<td>0.82</td>
</tr>
<tr>
<td>careen</td>
<td>6</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Table 2. Phytochemical constituents of *P. khinjuk* essential oil.

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Peak number</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>α-pinene (terpene)</td>
<td>1</td>
<td>78.71</td>
</tr>
<tr>
<td>β-Pinene (monoterpene)</td>
<td>2</td>
<td>11.73</td>
</tr>
<tr>
<td>trans-verbnom (monoterpene)</td>
<td>3</td>
<td>3.18</td>
</tr>
<tr>
<td>Bicyclo(3.1.1.)heptan (sesquiterpenes)</td>
<td>4</td>
<td>1.86</td>
</tr>
<tr>
<td>Verbenene (terpene)</td>
<td>5</td>
<td>1.22</td>
</tr>
<tr>
<td>Camphene (monoterpene)</td>
<td>6</td>
<td>1.2</td>
</tr>
<tr>
<td>D-limonene (monoterpene)</td>
<td>7</td>
<td>1.14</td>
</tr>
<tr>
<td>α-campholenal (monoterpene)</td>
<td>8</td>
<td>1.06</td>
</tr>
</tbody>
</table>

**Discussion**

![Fig. 1. GC-MS chromatogram of the essential oil of *P. atlantica*.](https://plantsciencetoday.online)

![Fig. 2. GC-MS chromatogram of the essential oil of *P. khinjuk*.](https://plantsciencetoday.online)
In our study, we extensively examined the phytochemical constituents and antioxidant properties of *Pistacia atlantica* and *P. khinjuk*. Our focus included determining the total phenol and flavonoid content, total antioxidant activity and IC50 (DPPH) of the hydroalcoholic extracts of *P. atlantica* and *P. khinjuk*. The results revealed that α-pinene, camphene, β-pinene, cyclohexene, D-limonene, and careen were the primary phytochemicals in *P. atlantica* essential oil. Consistent with other studies, our findings align with the presence of important phytochemicals like terpenes, terpenoids, and gallic acid in *P. atlantica* essential oil (19). Our findings align with previous studies that have identified various chemical compounds in *P. atlantica*. Gourine et al. (20) reported results consistent with ours, indicating α-pinene, camphene, β-pinene, and p-cymene as major phytochemical compounds in *P. atlantica*. While there are similarities in the types of chemical compounds between our study and Gourine’s, variations in percentages may be attributed to differences in the geographical source of the herb and the specific plant part under investigation (18). Our results are also consistent with other investigations. For example, Mahmoudvand et al. (21) found that the main phytoconstituents in the methanolic extract of *P. atlantica* were limonene, β-myrcene, and α-pinene. Turning to *P. khinjuk*, our data demonstrated that α-pinene, β-Pinene, camphene, cyclohexene, D-limonene, and careen were major phytochemical components in the essential oil. This is in line with a study by Taghizadeh et al. (11), where α-pinene, myrcene, and limonene were identified as main phytoconstituents in *P. khinjuk*. Several investigations have indicated that medicinal plants of the *Pistachio* genus, particularly *P. atlantica* and *P. khinjuk*, boast a high content of phenolic compounds (12, 22). Our findings support this, revealing a high content of total phenol for both the plants.

In our study, we extensively examined the phytochemical constituents and antioxidant properties of *Pistacia atlantica* and *P. khinjuk*. Our focus included determining the total phenol and flavonoid content, total antioxidant activity and IC50 (DPPH) of the hydroalcoholic extracts of *P. atlantica* and *P. khinjuk*. The results revealed that α-pinene, camphene, β-pinene, cyclohexene, D-limonene, and careen were the primary phytoconstituents in *P. atlantica* essential oil. Consistent with other studies, our findings align with the presence of important phytochemicals like terpenes, terpenoids, and gallic acid in *P. atlantica* essential oil (19). Our findings align with previous studies that have identified various chemical compounds in *P. atlantica*. Gourine et al. (20) reported results consistent with ours, indicating α-pinene, camphene, β-pinene, and p-cymene as major phytochemical compounds in *P. atlantica*. While there are similarities in the types of chemical compounds between our study and Gourine’s, variations in percentages may be attributed to differences in the geographical source of the herb and the specific plant part under investigation (18). Our results are also consistent with other investigations. For example, Mahmoudvand et al. (21) found that the main phytoconstituents in the methanolic extract of *P. atlantica* were limonene, β-myrcene, and α-pinene. Turning to *P. khinjuk*, our data demonstrated that α-pinene, β-Pinene, camphene, cyclohexene, D-limonene, and careen were major phytochemical components in the essential oil. This is in line with a study by Taghizadeh et al. (11), where α-pinene, myrcene, and limonene were identified as main phytoconstituents in *P. khinjuk*. Several investigations have indicated that medicinal plants of the *Pistachio* genus, particularly *P. atlantica* and *P. khinjuk*, boast a high content of phenolic compounds (12, 22). Our findings support this, revealing a high content of total phenol for both the plants.

![Figure 3](image-url)  
**Figure 3.** Mean and standard deviation of total phenol content (mg GAE/100 g dry extract) of the hydroalcoholic extracts of *P. atlantica* and *P. khinjuk*. ns: non-significant.

![Figure 4](image-url)  
**Figure 4.** Average of total flavonoid content (mg QE/100 g dry extract) of the hydroalcoholic extracts of *P. atlantica* and *P. khinjuk*. *: P<0.05

![Figure 5](image-url)  
**Figure 5.** Average of total antioxidant capacity (μmol AAE/100 g dry extract) of the hydroalcoholic extracts of *P. atlantica* and *P. khinjuk*. *: P<0.05.

### Table 3. Mean and standard deviation of total phenol and flavonoid content, total antioxidant potential and IC50 (DPPH) of the hydroalcoholic extracts of *P. atlantica* and *P. khinjuk*.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plant Sample</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phenol Content (mg GAE/100 g dry extract)</td>
<td>723.3750 ± 102.49957</td>
<td>0.6935</td>
</tr>
<tr>
<td>Total Flavonoid Content (mg of quercetin equivalent/100 g dry extract)</td>
<td>5.0485 ± 0.60374</td>
<td>0.0396</td>
</tr>
<tr>
<td>Total Antioxidant Capacity (μmol of ascorbic acid equivalent/100 g dry extract)</td>
<td>0.2427 ± 0.06296</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>IC50 (DPPH) (μg/mL)</td>
<td>872.94</td>
<td>1094.14</td>
</tr>
</tbody>
</table>

Importantly, no significant difference was observed in total phenolic content between the two species. Hatamnia et al. (23) also reported a high content of phenolic compounds in *P. atlantica* in a similar study. The data obtained are consistent with the results of our study, reinforcing the understanding that *P. atlantica* contains a variety of phenolic compounds, such as caffeic acid, coumaric acid, cinnamic acid, and ferulic acid (24). A study was conducted by Hazrati and colleagues, which determined that *P. khinjuk* plant contains phenolic compounds. Similarities in the high content of phenolic compounds between our study and Hazrati and colleagues work are evident. In Hazrati et al’s. research, a significant difference in total phenolic con-
tent between P. atlantica and P. khinjuk was observed with higher phenolic content in P. khinjuk than in P. atlantica (22). However, in our study, no significant difference was found in total phenolic content between P. atlantica and P. khinjuk. This inconsistency could be attributed to variations in the geographical source of the herb and the tested part of the plants (18). Our findings demonstrated a higher content of total flavonoids for both P. atlantica and P. khinjuk. There was also a significant difference in the total flavonoid content between P. atlantica and P. khinjuk. A number of recent studies have suggested elevated levels of total flavonoids for P. atlantica and P. khinjuk (23, 25, 26). Flavonoids, a class of polyphenols abundant in plants, vegetables, and fruits, encompass various subgroups such as flavonol, flavone, flavonone, and anthocyanin families. A wealth of evidences supports multifaceted benefits of flavonoids, including anti-microbial, anti-viral, anti-atherosclerotic, cardiotonic, anti-diabetic, antioxidant and anti-inflammatory properties (27). A recent study reported a significant difference in total flavonoid content between P. atlantica and P. khinjuk (22). Interestingly, our study did not find a significant difference in total flavonoid content between P. atlantica and P. khinjuk. Various factors, such as differences in growth conditions and the tested parts of these plants, may contribute to such discrepant results (18). In addition to studying flavonoids, we explored the total antioxidant potential of the hydroalcoholic extracts of P. atlantica and P. khinjuk. Our results revealed a high capacity of the total antioxidant in P. atlantica and P. khinjuk. This aligns with the extensive research conducted in recent years, with studies such as Fathollahi et al. (28) emphasizing the high antioxidant activity of P. atlantica. Additionally, Ahmed et al. (29) and Azadpour et al. (30) independently confirmed the robust antioxidant activity of P. atlantica and P. khinjuk, respectively. These findings support our own observations of high total antioxidant capacity in both the plants. The prevalence of chronic and non-chronic, infectious and non-infectious diseases has surged in recent times (31-36). Recognizing the therapeutically potential of medicinal plants, the human society has increasingly turned to them for disease treatment. Medicinal plants are known for their richness in antioxidants, flavonoid compounds, phenols, flavones, anthocyanins, and tannins (37-41).

Scientific studies have consistently demonstrated the antioxidant effects of many medicinal plants, making them valuable candidates for disease treatment (42-48). In our investigation, we observed that the total antioxidant capacity of P. khinjuk was notably higher than that of P. atlantica. This aligns with the findings of Hazrati and colleagues, who similarly reported a significantly higher total antioxidant capacity for P. khinjuk compared to P. atlantica. The widely accepted notion is that the high contents of phenolic compounds play a pivotal role in conferring antioxidant potential to various medicinal plants (22). In another facet of our study, we assessed antioxidant activity using the DPPH assay, revealing P. atlantica as a potent antioxidant through the efficient scavenging of DPPH free radicals. The IC_{50} value, representing the concentration of extract required for 50% quenching of DPPH free radicals, was notably lower, indicative of increased antioxidant power (18). This aligns with the consensus among several researchers who have independently confirmed the remarkable antioxidant activity of both P. atlantica and P. khinjuk, particularly in their ability to quench DPPH free radicals (28, 30). We recognize several limitations in our study that warrant acknowledgment. A primary limitation lies in the potential inadequacy of the methods employed to measure the antioxidant capacity of plants, which could impact the precision of our experimental results. Additionally, it is crucial to note that solely examining chemical compounds may not always be sufficient for a comprehensive evaluation of the antioxidant properties of herbs.

**Conclusion**

Based on the conducted research, it can be concluded that Pistacia atlantica and P. khinjuk are rich sources of phytochemical constituents, including phenolic and flavonoid compounds. The results indicate that P. atlantica and P. khinjuk exhibit significant antioxidant properties, as evidenced by their total antioxidant capacity and their ability to quench DPPH free radicals. These findings suggest that P. atlantica and P. khinjuk hold promise for medicinal and pharmaceutical purposes. However, further experiments will be needed to validate the therapeutic aspects of these plants.

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**Authors contributions**

HD, SMMH supervised the project. FN, HA perform and analyze the experiments, all the authors have written the manuscript, reviewed the manuscript and agreed to submit it.

**Compliance with ethical standards**

**Conflict of interest:** No conflict of interest was stated by the authors.

**Ethical issues:** None.

**References**


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