

Phytochemical Characterization and evaluation of the Antioxidant Potential of phenolic extracts of Eight Medicinal Plants

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Abstract

This study aimed to valorize eight medicinal plants commonly used by the Algerian population and to characterize their phytochemical composition and in vitro antioxidant activity. The species investigated were *Atriplex halimus*, *Salvia officinalis*, *Elettaria cardamomum*, *Glycine max*, *Panax ginseng*, *Origanum majorana*, *Pimpinella anisum*, and *Lepidium sativum*. The extracts were prepared by maceration using a hydro-methanolic solvent. Extraction yield was determined, while the main classes of secondary metabolites were identified through qualitative phytochemical screening. Total polyphenol content was determined using the Folin–Ciocalteu method, with gallic acid as the reference standard. The antioxidant activity of the extracts was subsequently evaluated using two complementary free-radical-scavenging assays, DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS [2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)], by UV–Visible spectrophotometry.

The results showed considerable variation in extraction yields among the investigated species, with the highest yield obtained for *Panax ginseng*. *Origanum majorana* exhibited the highest total polyphenol content. Both assays revealed variable radical-scavenging activity among the studied species, with particularly high activity observed for the extracts of *Salvia officinalis* and *Elettaria cardamomum*. These findings highlight the phytochemical diversity of the investigated plants and their potential as natural sources of antioxidant compounds.

Keywords: Medicinal plants, phenolic extract, DPPH test, phytochemical characterisation, antioxidant activity.

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Introduction

For centuries, medicinal plants have played an important role in traditional healthcare owing to their diverse biological and therapeutic properties. According to the World Health Organization (WHO, 2013), a substantial proportion of the global population relies on traditional medicine, including plant-based preparations, as part of primary healthcare. Medicinal plants therefore represent an important source of bioactive substances and have attracted increasing scientific interest.

The diverse biological properties of medicinal plants are largely associated with their richness in secondary metabolites. Among these compounds, polyphenols, flavonoids, tannins, alkaloids, and terpenoids constitute important phytochemical groups. These compounds are involved in various biological processes and may exert several biological activities, particularly antioxidant, anti-inflammatory, and antimicrobial effects (Khan et al., 2022). Among these metabolites, phenolic compounds have attracted particular attention because of their ability to interact with reactive species and contribute to antioxidant defense mechanisms.

Oxidative stress results from an imbalance between the production of reactive oxygen species (ROS) and the capacity of antioxidant defense systems to neutralize them. When ROS production becomes excessive, these reactive species can cause

oxidative damage to various cellular components, including lipids, proteins, and nucleic acids (Favier, 2006; Hamma et al., 2015). Consequently, the identification of natural sources capable of neutralizing reactive species has become an important area of research in the study of plant-derived bioactive compounds.

In this context, medicinal plants represent potential sources of natural antioxidant compounds. Their antioxidant activity is particularly associated with the presence and concentration of phenolic and flavonoid compounds. The investigation of these properties therefore requires prior characterization of the phytochemical composition of plant extracts as well as an assessment of their phenolic content. Qualitative phytochemical screening provides preliminary information on the major classes of secondary metabolites present in plant extracts, whereas the determination of total polyphenol content provides an overall estimate of their phenolic richness. In addition, antioxidant activity can be evaluated using different in vitro assays, particularly the DPPH and ABTS radical-scavenging assays.

Accordingly, the present study aimed to characterize the phytochemical composition of eight medicinal plants traditionally used in Algeria. The study focused on the qualitative phytochemical screening of the extracts, the

determination of their total polyphenol content, and the evaluation of their in vitro antioxidant activity using the DPPH and ABTS radical-scavenging assays. These approaches provide complementary information on the phytochemical profiles of the studied species and contribute to the scientific characterization of their potential as natural sources of antioxidant compounds

Materials and methods

1. Plant material

Eight (08) food and medicinal plants were selected following a questionnaire survey conducted in the Relizane region. The survey focused on plants commonly used in dietary practices and traditional healthcare. This questionnaire made it possible to identify the plant species most frequently cited and used by the local population. The species selected for this study were: *Atriplex halimus*, *Salvia officinalis*, *Elettaria cardamomum*, *Glycine max*, *Panax ginseng*, *Origanum majorana*, *Pimpinella anisum* and *Lepidium sativum*. The selection of these species was based on their frequency of citation, their reported uses in food and traditional medicine, and their availability in the study region.

2. Collection, drying and grinding of selected plant parts

The selected plants were purchased from herbalists and local markets in Relizane Province, northwestern Algeria, during the period from 06/02/2026 to 22/02/2026. The different plant organs were dried under air conditioning at 16 °C for five days for leaves and two weeks for bark and succulent leaves. The dried organs were ground using a mortar and then a blender. Fine powdered samples were obtained and stored in Kraft paper envelopes at room temperature until use for phytochemical tests, polyphenol determination and antioxidant activity evaluation.

3. Preparation of crude extracts

The extraction method used was maceration. Thus, 10 g of plant powder were macerated in 200 mL of a methanol/water mixture (70:30, v/v) at room temperature under agitation for 48 h. After maceration, the extract was recovered by filtration through Whatman filter paper. The solvent was then evaporated at 40 °C under reduced pressure using a rotary evaporator to obtain the crude extract.

4. Extraction yield

The extraction yield is the ratio between the weight of the extract obtained after solvent evaporation and the weight of the dry plant subjected to extraction. It is expressed as a percentage and calculated using the following formula:

$$R (\%) = \frac{\text{Mass of flask after evaporation} - \text{Mass of empty flask}}{\text{Sample mass}} \times 100$$

(1) Where: Mass of flask after evaporation – Mass of empty flask / Mass of crude extract (g) (Boubekri, 2014).

5. Qualitative phytochemical screening of extracts

Phytochemical tests were carried out on the different extracts studied. Table 1: Qualitative identification of phytochemical groups in the extracts

Phytochemical Groups	Principle Reagents Used	Procedure	Positive Result
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Tannins	1% FeCl ₃	Add 3 drops of FeCl ₃ to 1 mL of extract, then incubate for 2 min.	Appearance coloration.
Flavonoids	37% HCl magnesium turnings (Mg)	Treat 2 mL of extract with a few drops of 37% HCl, then add 0.5 g of Mg.	Appearance of a red or coloration.
Terpenoids	Chloroform	Add 1 mL of chloroform and 1.5 mL of concentrated H ₂ SO ₄ to 2.5 mL of extract.	Formation of two phases with a brown coloration at the interface.
Sterols (Liebermann–Burchard reaction)	Acetic anhydride H ₂ SO ₄	Mix 1 mL of extract with 2.5 mL of acetic anhydride, then add 10 drops of concentrated H ₂ SO ₄ .	Appearance of a purple coloration turning green.
Alkaloids	1% HCl Mayer's	Add 2.5 mL of 1% HCl to 0.1 mL of extract and heat in a water bath for 10 min. Divide the solution into two portions and add Mayer's and Wagner's reagents, respectively.	Appearance of a white or brown precipitate.

Free quinones	1% NaOH	Add a few drops of 1% NaOH to 1 mL of extract.	Appearance of violet coloration.
Saponins	Distilled water	Add distilled water to 2 mL of extract and shake vigorously for 1 min.	Formation 15 min with a thickness > 1 cm.
Reducing compounds	Fehling's solutions A and B	Add 0.5 mL of Fehling's solution A and Fehling's solution B to 1 mL of extract, then heat in a water bath at 100 °C.	Formation

6. Determination of total polyphenol content

The total polyphenol content of the studied plant extracts was determined using the Folin–Ciocalteu reagent according to the method described by Wong et al. (2006), using gallic acid as the standard. This assay is based on the quantification of the total concentration of hydroxyl groups present in the extract. When polyphenols are oxidized, they reduce the Folin–Ciocalteu reagent, leading to the formation of a blue-colored complex. The intensity of this coloration is proportional to the concentration of total polyphenols present in the extract. The absorbance of each extract was measured using a spectrophotometer at a wavelength of 760 nm. The total polyphenol concentration was determined from the gallic acid calibration curve. The results were expressed as micrograms of gallic acid equivalents per milligram of extract (µg GAE/mg extract).

7. Determination of antioxidant activities

Antioxidant activities were determined using two methods: DPPH (1,1-diphenyl-2-picrylhydrazyl) and ABTS (2,2-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)).

7.1. DPPH assay

To 100 µL of extract, 2500 µL of a 0.4 mM methanolic DPPH solution were added. The resulting mixture was incubated in the dark for 30 min at 30 °C, and the absorbance was measured at 517 nm against a methanol blank. The assays were repeated three times. The percentage inhibition of the DPPH radical was calculated according to the following formula:

% Inhibition (DPPH) $[(A_0 - A_i) / A_0] \times 100$ (2) Where: A0: Absorbance of the control, Ai: absorbance of the extract. The DPPH radical scavenging capacity was expressed as mg Trolox equivalents g⁻¹ of extract (mg TE g⁻¹ extract) according to the formula of Wangcharoen and Morasuk (2007): Value (mg TE g⁻¹ DM) = $[(A_0 - A_1) / (\text{Slope})] (V/v) / (m \times 1000)$ (3) Where: A1: Absorbance value of the sample. A0: Absorbance value of the control. Slope: Slope of the regression line expressing the absorbance values as a function of the different Trolox concentrations. V: Total volume of the extract prepared to obtain the stock

solution. v: Volume of the extract taken for the test. m: Mass of the sample taken to prepare the stock solution. 1000: Conversion factor (µg to mg).

7.2. ABTS assay

The ABTS⁺ cation was obtained by mixing (v/v) ABTS (7.0 mM) and potassium persulfate (2.6 mM), followed by incubation in the dark at room temperature overnight. One milliliter of the ABTS⁺ solution was diluted with 60 mL of methanol to obtain an absorbance between 1 and 1.5 at 734 nm. The solution was prepared immediately before testing and could not be stored. To 100 µL of the plant methanolic extract, 2500 µL of ABTS⁺ solution were added, and the mixture was incubated in the dark for 2 hours.

The percentage inhibition of the ABTS⁺ radical was calculated according to the following formula:

% Inhibition (ABTS⁺) = $[(A_a - A_b) / A_a] \times 100$ (4) Where: Aa: Absorbance of the control, Ab: absorbance of the extract. The ABTS radical scavenging capacity was expressed as mg Trolox equivalents g⁻¹ of extract (mg TE g⁻¹ extract) according to the formula described by Wangcharoen and Morasuk (2007). The same procedure was applied for the synthetic antioxidant (Trolox), used as the positive control.

8. Statistical analysis

Statistical analysis was performed using one-way analysis of variance (one-way ANOVA), followed by Tukey's multiple comparison test. Differences were considered statistically significant at $p < 0.05$ (Vessereau, 1992).

Results

1. Extraction yields

The extraction yields obtained from the different medicinal plants investigated are reported in Table 2. The results revealed considerable variation among the extracts. The highest extraction yield was obtained for Panax ginseng ($16.8 \pm 0.29\%$), whereas Elettaria cardamomum showed the lowest yield ($1.2 \pm 0.37\%$). The other species exhibited intermediate yields: Atriplex halimus ($8.2 \pm 0.46\%$), Origanum majorana ($6.7 \pm 0.22\%$), Glycine max ($4.9 \pm 0.23\%$), Pimpinella anisum ($4.7 \pm 0.19\%$), Salvia officinalis ($4.0 \pm 0.33\%$), and Lepidium sativum ($3.1 \pm 0.28\%$).

Statistical analysis using Tukey's post hoc test revealed significant differences among the extraction yields of the studied plants ($p < 0.05$). Panax ginseng (a) exhibited a significantly higher yield than all other extracts. Atriplex halimus and Origanum majorana (b) did not differ significantly from each other but showed significantly higher yields than plants belonging to groups c, d, and e. In contrast, Elettaria cardamomum (e) exhibited the lowest yield and differed significantly from most of the other extracts. Groups sharing at least one common letter were not significantly different.

2. Qualitative phytochemical screening of the extracts

Qualitative phytochemical screening of the hydro-methanolic extracts revealed the presence of several groups of secondary metabolites, with varying intensities among the studied species (Table 3). Tannins and flavonoids were widely distributed, with the strongest reactions for tannins observed in Salvia officinalis and Elettaria cardamomum, and for flavonoids in Glycine max, Salvia officinalis, Elettaria cardamomum, and Origanum majorana. Terpenoids were also strongly detected in Panax

ginseng, *Pimpinella anisum*, *Elettaria cardamomum*, and *Origanum majorana*. Steroids and alkaloids were detected at varying intensities among the species, whereas free quinones showed a more restricted distribution. Saponins were detected in all extracts, with the highest abundance observed in *Panax ginseng*. Finally, reducing compounds were present in all studied species, mainly at low to moderate levels. Overall, these findings highlight the considerable phytochemical diversity of the investigated plants.

3. Total polyphenol content of the extracts

The total polyphenol content of the different plant extracts was determined using the Folin–Ciocalteu method, with gallic acid as the reference standard. The results are expressed as $\mu\text{g GAE/mg}$ extract and are presented in Figure 2. Statistical analysis revealed significant differences among the extracts. The *Origanum majorana* extract exhibited the highest total polyphenol content ($147.37 \pm 0.090 \mu\text{g GAE/mg}$), which was significantly higher than that of all other extracts ($p < 0.05$), and was assigned to group a. It was followed by *Salvia officinalis* ($98.11 \pm 0.19 \mu\text{g GAE/mg}$), belonging to group b.

Intermediate polyphenol contents were observed for *Pimpinella anisum* ($54.23 \pm 0.07 \mu\text{g GAE/mg}$), *Lepidium sativum* ($52.78 \pm 0.043 \mu\text{g GAE/mg}$), *Atriplex halimus* ($51.21 \pm 0.12 \mu\text{g GAE/mg}$), and *Glycine max* ($50.92 \pm 0.049 \mu\text{g GAE/mg}$). These extracts belonged to the same group c and did not differ significantly from each other ($p > 0.05$). In contrast, *Elettaria cardamomum* ($28.03 \pm 0.049 \mu\text{g GAE/mg}$), belonging to group d, exhibited a significantly lower polyphenol content. Finally, *Panax ginseng* ($17.33 \pm 0.064 \mu\text{g GAE/mg}$), assigned to group e, showed the lowest total polyphenol content. Haut du formulaire Bas du formulaire

4. Potential of the extracts to scavenge the ABTS⁺ radical

The results of the antioxidant activities of the hydro-methanolic extracts against the ABTS⁺ radical are presented in Table 4. The extracts from *Salvia officinalis* leaves and *Elettaria cardamomum* seeds exhibited the highest activities, inhibiting the ABTS⁺ radical by $98.89 \pm 0.02\%$ and $89.99 \pm 0.11\%$, respectively. They also showed the highest antioxidant capacities, with values of 337.51 ± 0.11 and $304.53 \pm 0.12 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$, respectively.

Regarding ABTS⁺ radical-scavenging activity, *Salvia officinalis* exhibited the highest value ($98.89 \pm 0.02\%$, group a), followed by *Elettaria cardamomum* ($89.99 \pm 0.11\%$, group b) and *Lepidium sativum* ($78.34 \pm 0.47\%$, group b). Sharing the same letter (b) indicates that there was no significant difference between *Elettaria cardamomum* and *Lepidium sativum* according to Tukey's test ($p < 0.05$). *Origanum majorana* leaves showed an activity of $73.38 \pm 0.39\%$ (group c), while *Glycine max* and *Panax ginseng* exhibited activities of $72.76 \pm 0.19\%$ and $72.23 \pm 0.10\%$, respectively, both belonging to group cd. Thus, these two extracts did not differ significantly from each other and were also statistically comparable to *Origanum majorana* due to the shared letter c. *Pimpinella anisum* showed an activity of $69.18 \pm 0.23\%$ (group de), whereas *Atriplex halimus* exhibited the lowest value ($68.13 \pm 0.22\%$, group e). The shared letter e indicates that these two extracts did not differ significantly from each other.

Regarding antioxidant capacity determined by the ABTS method, *Salvia officinalis* also exhibited the highest value ($337.51 \pm 0.11 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$, group a), followed by *Elettaria cardamomum* ($304.53 \pm 0.12 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$) and *Lepidium sativum* ($268.66 \pm 0.33 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$), both belonging to group

b and therefore showing no significant difference between them. *Origanum majorana* exhibited a capacity of $231.89 \pm 0.21 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$ (group c), while *Glycine max* and *Panax ginseng* recorded values of 201.46 ± 0.23 and $198.40 \pm 0.33 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$, respectively, both belonging to group d, indicating no significant difference between these two extracts. The lowest values were observed for *Pimpinella anisum* ($168.13 \pm 0.32 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$) and *Atriplex halimus* ($165.24 \pm 0.26 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$), both belonging to group f, indicating no significant difference between these two extracts.

5. Antioxidant capacity determined by the DPPH method

The results obtained using the DPPH method also showed considerable variability in the antioxidant capacity of the different extracts (Table 4). *Salvia officinalis* exhibited the highest value, with $301.56 \pm 0.09 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$ (group a), followed by *Elettaria cardamomum* ($296.28 \pm 0.43 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$) and *Lepidium sativum* ($241.37 \pm 0.13 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$), which belonged to the same group b and therefore did not differ significantly from each other according to Tukey's test ($p < 0.05$).

Origanum majorana showed an antioxidant capacity of $211.56 \pm 0.23 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$, belonging to group c. *Glycine max* exhibited a value of $198.13 \pm 0.18 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$ (group d), while *Panax ginseng* recorded $178.65 \pm 0.13 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$ (group e). Finally, the lowest antioxidant capacities were observed for *Pimpinella anisum* ($153.23 \pm 0.27 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$) and *Atriplex halimus* ($147.18 \pm 0.17 \text{ mg TE}\cdot\text{g}^{-1} \text{ DW}$), both belonging to group f and therefore showing no significant difference between them.

Overall, the results obtained using both methods indicate that *Salvia officinalis* exhibited the highest antioxidant potential, followed mainly by *Elettaria cardamomum* and *Lepidium sativum*, whereas *Pimpinella anisum* and *Atriplex halimus* showed the lowest activities. The letters assigned by Tukey's test confirm the statistically significant differences or similarities observed among the extracts.

Table 2. Plant species, plant part used, and extraction yield of the hydro-methanolic extracts. Values are expressed as mean $\pm$ standard deviation (SD) ($n = 3$). Different letters indicate statistically significant differences among plant species according to Tukey's post hoc test ($p < 0.05$). Means sharing at least one common letter are not significantly different.

Plant species	Family	Plant part used	Efficiency (%)
<i>Panax ginseng</i>	Araliaceae	Roots	$16.8 \pm 0.29\text{a}$
<i>Atriplex halimus</i>	Amaranthaceae	Leaves	$8.2 \pm 0.46\text{b}$
<i>Origanum majorana</i>	Lamiaceae	Leaves	$6.7 \pm 0.22\text{b}$

Glycine max	Fabaceae	Seeds	4.9 ± 0.23c
Pimpinella anisum	Apiaceae	Seeds	4.7 ± 0.19c
Salvia officinalis	Lamiaceae	Leaves and stems	4.0 ± 0.33c
Lepidium sativum	Brassicaceae	Seeds	3.1 ± 0.28cd
Elettaria cardamomum	Zingiberaceae	Seeds	1.2 ± 0.37e

Table 3. Qualitative phytochemical screening of the hydro-methanolic extracts of the studied medicinal plants

Métabolites secondaires	Reaction	Glycine max	Atriplex halimus	Panax ginseng	Salvia officinalis	Pimpinella anisum	Lepidium sativum	Elettaria cardamomum	Origanum majorana
Tanins	FeCl ₃	++	++	+	+++	+	++	+++	++
Flavonoïdes	Mg/HCl	+++	++	++	+++	++	++	+++	+++
Terpénoides	Chloroform + H ₂ SO ₄	+	+	+++	++	+++	+	+++	+++
Sterols	Acetic anhydride + H ₂ SO ₄	+	++	++	+	++	+	+	+
Alcaloïdes	Wagner / Mayer	-	+	+	-	+	+	+	-
Free quinones	NH ₄ OH	-	-	-	+	-	-	+	+
Saponins	Foam test ≥ 1cm	++	+	+++	+	+	+	+	+
Reducing compounds	Fehlings reagent	++	+	++	+	++	++	++	+

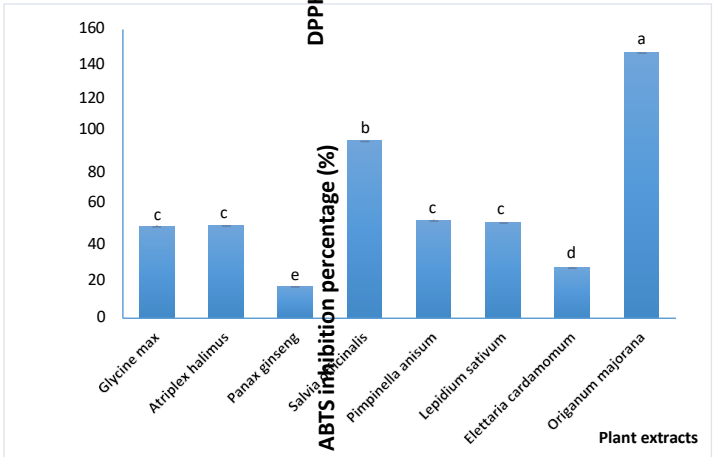
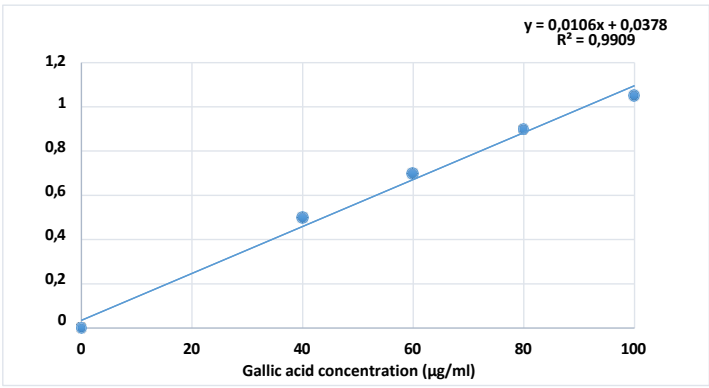


Figure 1. Calibration curve of gallic acid showing the relationship between gallic acid concentration (µg/mL) and absorbance. The linear regression equation and the coefficient of determination (R²) are presented.

Figure 2. Total phenolic content of the hydro-methanolic extracts of the studied medicinal plants, expressed as µg gallic acid equivalents (GAE) per mg of dry extract (µg GAE/mg dry extract). Values are presented as mean ± standard deviation (SD) (n = 3). Different letters above



the bars indicate statistically significant differences among plant extracts according to Tukey's post hoc test (p < 0.05). Bars sharing at least one common letter are not significantly different.

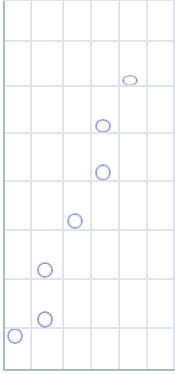


Figure 3. Calibration curve: DPPH inhibition percentage as a function of Trolox concentration (mg/ml). The linear regression equation and the coefficient of determination (R²) are presented.

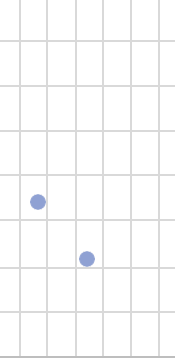
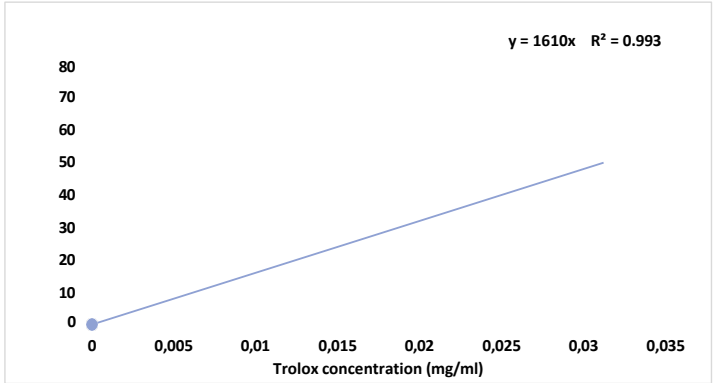
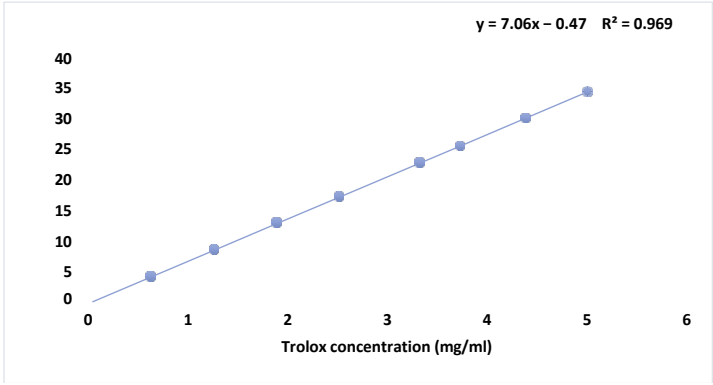


Figure 4. Calibration curve: ABTS inhibition percentage as a function of Trolox concentration (mg/ml). The linear regression equation and the coefficient of determination (R²) are presented.

Table 4. Antioxidant activities of the hydro-methanolic extracts of the studied medicinal plants. Values are expressed as mean ± standard deviation (SD) (n = 3). Different letters within the same column indicate statistically significant differences among plant extracts according to Tukey's post hoc test (p < 0.05). Means sharing at least one common letter are not significantly different.



Plant species	Plant part used	ABTS radical scavenging activity (%)	ABTS antioxidant capacity (mg TE/g dry matter ± SD)	DPPH antioxidant capacity (mg TE/g dry matter ± SD)
Glycine max	Seeds	72,76 ± 0,19cd	201,46 ± 0,23d	198,13 ± 0,18d
Salvia Officinalis	Leaves and stems	98,89 ± 0,02a	337,51 ± 0,11a	301,56 ± 0,09a
Origanum majorana	Leaves	73,38 ± 0,39c	231,89 ± 0,21c	211,56 ± 0,23c
Pimpinella anisum	Seeds	69,18 ± 0,23de	168,13 ± 0,32f	153,23 ± 0,27f
Panax ginseng	Roots	72,23 ± 0,10cd	198,4 ± 0,33d	178,65 ± 0,13e
Elettaria cardamomum	Seeds	89,99 ± 0,11b	304,53 ± 0,12b	296,28 ± 0,43b
Lepidium sativum	Seeds	78,34 ± 0,47c	268,66 ± 0,33b	241,37 ± 0,13b
Atriplex halimus	Leaves	68,13 ± 0,22e	165,24 ± 0,26f	147,18 ± 0,17f

Discussion

1. Extract yield

The extraction yields of the eight plants ranged from 1.2 to 16.8%, indicating substantial interspecific variability. This variation may be attributed to the phytochemical composition of the plants, solvent polarity, plant organ used, and extraction conditions (Azmir et al., 2013). Panax ginseng exhibited the highest extraction yield (16.8%), which is consistent with yields reported for its hydroalcoholic extracts, which are particularly rich in ginsenosides and polysaccharides (Christensen, 2009). In contrast, Elettaria cardamomum showed the lowest yield (1.2%), which may be related to its richness in volatile compounds, which are less efficiently recovered through hydromethanolic extraction (Marongiu et al., 2004). Differences from the

literature may also result from the geographical origin of the plants, their developmental stage, the plant organ used, and experimental parameters (Vági et al., 2005; Ghorbani et Esmailizadeh, 2017; Zennaf et al., 2022). Overall, these findings confirm that extraction yield is strongly dependent on the nature of the plant matrix and the extraction conditions.

2. Qualitative phytochemical screening

Phytochemical screening revealed the presence of several classes of secondary metabolites, including tannins, flavonoids, terpenoids, sterols, alkaloids, quinones, saponins, and reducing compounds. Tannins and flavonoids were widely represented, particularly in Salvia officinalis and Elettaria cardamomum, which may contribute to their antioxidant potential (Sharma et al., 2023). Terpenoids, detected in several species, are also associated with various biological activities, particularly antioxidant and antimicrobial effects (Camara et al., 2024). The presence of saponins in Glycine max and Panax ginseng is consistent with the known richness of these species in saponins, particularly ginsenosides in ginseng (Lee et al., 2022). The presence of reducing compounds in several extracts may also contribute to their antioxidant capacity (Vuolo et al., 2022). However, the qualitative nature of the screening does not allow the concentration or precise identity of the detected compounds to be determined.

3. Total polyphenol content

Total polyphenol contents showed substantial variability among the species, probably due to differences in their chemical composition, plant organ, raw material origin, and extraction conditions. Origanum majorana and Salvia officinalis exhibited the highest polyphenol contents, in agreement with the phenolic richness generally reported for Lamiaceae species (Vági et al., 2005; Dorman et al., 2004). The intermediate values observed for Glycine max, Atriplex halimus, Lepidium sativum, and Pimpinella anisum are also consistent with the variability reported in the literature, particularly depending on the solvent and plant organ used (Benhammou et al., 2009; Aydemir & Becerik, 2011). In contrast, Elettaria cardamomum and Panax ginseng exhibited the lowest contents, which may be explained by a composition more strongly dominated by other classes of metabolites (Mohamed et al., 2025; Kim et al., 2025). However, the Folin–Ciocalteu method provides an overall estimation of phenolic compounds and does not allow individual identification of the molecules responsible for the measured values. Thus, the observed differences confirm the phytochemical diversity of the studied species and highlight the influence of plant-related and experimental factors on polyphenol contents.

4. Antioxidant activity

The methanolic extracts of the studied plants exhibited variable antioxidant activity depending on the species, with an overall similar trend between the ABTS and DPPH assays. Salvia officinalis exhibited the highest activity, with 98.89% ABTS radical-scavenging activity and antioxidant capacities of 337.51 and 301.56 mg TE/g DW for the ABTS and DPPH assays, respectively. This high activity is consistent with several studies reporting the strong antioxidant potential of S. officinalis, particularly due to its richness in phenolic compounds such as rosmarinic acid and certain flavonoids (Lu & Foo, 2001; Poullos et al., 2020).

Elettaria cardamomum also exhibited considerable antioxidant activity, whereas Lepidium sativum, Origanum majorana,

Glycine max, and Panax ginseng showed intermediate activities. In contrast, Pimpinella anisum and particularly Atriplex halimus exhibited the lowest values. These differences may be related to the nature and concentration of phenolic and flavonoid compounds, as well as to the plant part used and extraction characteristics. The DPPH and ABTS assays primarily assess the ability of antioxidant molecules to neutralize radical species; however, their responses may vary depending on the chemical structure of the compounds present in the extracts (Prior et al., 2005; Apak et al., 2016).

Conclusion

The results obtained showed variability in extraction yields among the different plant species investigated. Qualitative phytochemical screening revealed the presence of several classes of secondary metabolites, including flavonoids, tannins, terpenoids, sterols, and saponins, with a variable distribution among the studied species. The analysis of total polyphenol content also revealed substantial differences among the extracts, with Origanum majorana exhibiting the highest content.

The evaluation of antioxidant activity using the DPPH and ABTS assays revealed differences among the investigated extracts. In particular, the leaf extracts of Salvia officinalis and the seed extracts of Elettaria cardamomum exhibited high radical-scavenging activity, suggesting the presence of compounds that may contribute to the neutralization of reactive species.

Overall, these findings highlight the phytochemical diversity of the eight plants investigated and their potential as natural sources of bioactive compounds. The results provide preliminary scientific evidence of their antioxidant potential and support further investigations, particularly the identification and quantification of the compounds responsible for this activity, as well as complementary studies to further elucidate their biological potential.

References

- [1] Apak R, Özyürek M, Güçlü K and Çapanoğlu E. (2016). Antioxidant activity/capacity measurement. 1. Classification, physicochemical principles, mechanisms, and electron transfer (ET)-based assays. Journal of Agricultural and Food Chemistry, vol. 64 (5), 997-1027.
- [2] Aydemir T and Becerik S. (2011). Phenolic Content and Antioxidant Activity of Different Extracts from Ocimum basilicum, Apium graveolens and Lepidium sativum Seeds. Journal of Food Biochemistry, vol. 35, p. 62-79.
- [3] Azmir J, Zaidul ISM and Rahman M. (2013). Techniques for extraction of bioactive compounds from plant materials: A review. Journal of Food Engineering, vol. 117 (4), p. 426-436.
- [4] Benhammou N, Atik-Bekkara F and Panovska TK. (2009). Antioxidant activity of methanolic extracts and some bioactive compounds of Atriplex halimus. Comptes Rendus Chimie, vol. 12 (12), p. 1259-1266.
- [5] Boubekri C. (2014). Etude de l'activité antioxydante des polyphénols extraits de Solanum melongena par des techniques électrochimiques. Thèse pour l'obtention du Doctorat en science, Université Mohamad Khider Biskra, p. 19-45.
- [6] Camara JS, Perestrelo R, Ferreira R, Berenguer CV, Pereira JAM and Castilho PC. (2024). Plant-Derived Terpenoids: A Plethora of Bioactive Compounds with Several Health Functions and Industrial Applications-A Comprehensive Overview. Molecules (Basel, Switzerland), vol. 29 (16), p. 3861.
- [7] Christensen LP. (2009). Ginsenosides: Chemistry, biosynthesis, analysis, and potential health effects. Advances in Food and Nutrition Research, vol. 55, p. 1-99.
- [8] Dorman HJ, Bachmayer O, Kosar M and Hiltunen R. (2004). Antioxidant properties of aqueous extracts from selected lamiaceae species grown in Turkey. Journal of agricultural and food chemistry, vol. 52 (4), p. 762-770.
- [9] Favier A. (2006). Stress oxydant et pathologies humaines. Ann Pharm Françaises, 64, p. 390-396
- [10] Ghorbani A, Esmailizadeh M. (2017). Pharmacological properties of Salvia officinalis and its components. Journal of traditional and complementary medicine, vol. 7(4), p. 4336-440.
- [11] Hamma SA, Nouri N, Fergani I, Lekhal A, Cheriet S, Abadi N, Lezzar A and Benlatreche C. (2015). Biologie des espèces réactives et stress oxydant. Journal Algérien de Médecine, XXIII (2), 48-53
- [12] Kim HJ, Cho JY and Kim MY. (2025). A comprehensive review of the effects of Panax ginseng and its constituents against inflammatory diseases. Journal of ginseng research, vol. 49(6), p. 605-612.
- [13] Khan H, Ullah H and Tundis R. (2022). Dietary polyphenols in the management of menopause symptoms. Phytotherapy Research, vol. 36 (4), p. 1525-1540.
- [14] Lee SY, Kim YK and Park NI. (2022). Ginsenosides and biological activities of Panax ginseng. Journal of Ginseng Research, vol. 46, p. 1-13.
- [15] Lu Y and Foo LY. (2001). Antioxidant activities of polyphenols from sage (Salvia officinalis). Food Chemistry, vol. 75 (2), p. 197-202.
- [16] Marongiu B, Piras A, Porcedda S, Falconieri D and Gonçalves MJ. (2004). Chemical composition and comparison of the essential oils obtained by supercritical CO₂ extraction and hydrodistillation from Elettaria cardamomum (L.) Maton. Journal of Agricultural and Food Chemistry, vol. 52 (20), p. 6278-6282.
- [17] Mohamed D, Hamed I and Mabrok HB. (2025). Cardamom extract: An effective weapon in prevention of cardiorenal syndrome induced in rats by cisplatin and high-fat diet. World J Nephrol, vol. 14, (3):107736.
- [18] Poullos E, Giaginis C and Vasios GK. (2020). Current state of the art on the antioxidant activity of sage (Salvia spp.) and its bioactive components. Planta Medica, vol. 86 (4), p. 224-238.
- [19] Prior RL, Wu X and Schaich K. (2005). Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements. Journal of Agricultural and Food Chemistry, vol. 53(10), p. 4290-4302.
- [20] Sharma A, Gupta P and Singh B. (2023). Phenolic compounds and antioxidant potential of medicinal plants. Plants, vol. 12, p. 2217.
- [21] Vági E, Rapavi E, Hadolin M, Vasarhelyiné P, Balázs A, Blázovics A and Simándi B. (2005). Phenolic and triterpenoid antioxidants from Origanum majorana L. herb and extracts obtained with different solvents. Journal of Agricultural and Food Chemistry, vol. 53 (1), p. 17-21.
- [22] Vessereau A. (1992). Méthodes statistiques en biologie et en agronomie. Technique et documentation.

Lavoisier, Paris, 538.

[23] Vuolo MM, Lima VS and Maróstica MR. (2022). Phenolic compounds and reducing capacity in plant extracts. *Antioxidants*, vol. 11, p. 1649.

[24] Wangcharoen, W., & Morasuk, W. (2007). Antioxidant capacity and phenolic content of holy basil. Songklanakarin. *Journal of Science and Technology*, vol. 29 (5), p. 1407-1415.

[25] Wong SP, Leong LP and Koh JHW. (2006). Antioxidant activities of aqueous extracts of selected plants. *Food Chemistry*, vol. 99 (4), p. 775-783.

[26] World Health Organization. (2013). WHO traditional medicine strategy 2014–2023. Geneva.

[27] Zennaf I, Meddah A, Meddah B and Mokhtar M. (2022). Ethnobotanical and Phytochemical Study of the Medicinal Plant *Atriplex halimus*. French-Ukrainian. *Journal of Chemistry*, vol. 10 (1), p. 60-69.