Bitki Koruma Bülteni / Plant Protection Bulletin

http://dergipark.gov.tr/bitkorb

Orijinal araştırma (Original article)

Otospermum glabrum extracts: antioxidant properties and bioactivity against fungal pathogens and *Aphis fabae*

Otospermum glabrum özleri: fungal patojenlere ve *Aphis fabae*'ye karşı antioksidan özellikler ve biyoaktivite

Mohammed ALLOUANI[a,b], Noui HENDEL[a,b*], Dahou MOUTASSEM[c], Djamel SARRI[d], Madani SARRI[d], Abdallah KHERBACHE[a], Meriem SAHRAOUI[e]

https://orcid.org/0009-0001-4298-6432, https://orcid.org/0000-0002-6577-925X, https://orcid.org/0000-0001-6103-9134, https://orcid.org/0000-0002-7112-0400, https://orcid.org/0009-0007-7351-2006, https://orcid.org/0000-0002-5615-9681, https://orcid.org/0009-0003-5206-0486

[a]*Department of Microbiology and Biochemistry, Faculty of Sciences, University of M'sila, University pole, Road Bordj Bou Arreridj ,M'sila 28000, Algeria*

[b] *Laboratory of Biology: Applications in Health and Environment, University of M'sila, University pole, Road Bordj Bou Arreridj, M'sila 28000, Algeria*

[c] *Laboratory of Characterization and Valorization of Natural Resources (L.C.V.R). Faculty of Life and Natural Sciences and of Earth and Universe Sciences, Mohamed El Bachir El Ibrahimi University, Bordj Bou Arreridj, 34000, Algeria*

[d] *Department of Nature and Life Sciences, Faculty of Sciences, University of M'sila, University pole, Road Bordj Bou Arreridj, M'sila 28000, Algeria*

[e] *Laboratoire de Technologies Douces,Valorisation, Physico – Chimie des Matériaux Biologique et Biodiversité. (Université M'Hamed Bougerra Boumerdès)*

ARTICLE INFO

Article history:

DOI: 10.16955/bitkorb.1613134

Received : 04-01-2025

Accepted : 31-05-2025

Keywords:

Otospermum glabrum, polyphenols, antioxidant activity, antifungal activity, aphicidal activity

* Corresponding author: Noui HENDEL

noui.hendel@univ-msila.dz

ABSTRACT

The adoption of plant-based biopesticides as sustainable alternatives to synthetic chemicals in agricultural pest management has gained increasing attention due to their safety and ecological benefits. Many of these natural compounds demonstrate potent antifungal activity, mitigating foodborne fungal contamination and associated mycotoxins. This study evaluated the antioxidant, antifungal, and aphicidal potential of *Otospermum glabrum* (Asteraceae) extracts derived from its aerial parts. Three extracts −ethyl acetate, methanolic, and aqueous− were assessed for total polyphenolic and flavonoid contents, antioxidant activity (DPPH radical scavenging, β-carotene bleaching, and total antioxidant capacity), antifungal effects against six post-harvest and crop fungal pathogens, and aphicidal activity against the black bean aphid (*Aphis fabae* Scop.). The ethyl acetate extract (EaE) exhibited the highest polyphenols (57.60 ± 0.17 µg GAE/mg) and flavonoids (49.46 ± 0.66 µg QE/mg), while the methanolic extract (ME) demonstrated the strongest DPPH scavenging activity (IC_{50} = 56.05 ± 0.03 µg/ml) and β-carotene bleaching inhibition, comparable to BHT. The aqueous and ethyl acetate extracts showed the highest total antioxidant capacity (252.60 ± 0.20 and 249.10 ± 0.81 µg AAE/mg, respectively). Antifungal assays revealed that ethyl acetate and methanolic extracts were the most effective, with inhibition percentages (IP) exceeding 65% against all tested fungi. Additionally, the methanolic extract at 30% concentration induced 100% mortality in A. fabae after 72 h and exhibited significant repellency (48.98 ± 8.76%). These findings highlight *O. glabrum* as a promising source of natural biopesticides for integrated pest management.

INTRODUCTION

Ensuring food security is essential for sustaining the growing populations of both humans and animals. Food stability can be significantly impacted by unexpected challenges in food production caused by various organisms, including bacteria, viruses, fungi, and insects (Hendel et al. 2021, Mwangi et al. 2023).

Fungal pathogens are responsible for 70–80% of microbial-related agricultural losses, with approximately 8.000 species causing nearly 100.000 plant diseases, while recent studies report over 19.000 fungal species as phytopathogens (Deresa and Diriba 2023). Highly destructive genera such as *Aspergillus*, *Penicillium*, and *Fusarium* induce critical crop diseases; including corn ear rot (*Fusarium* spp.), cotton boll rot (*Aspergillus* spp.), grape blue mold (*Penicillium* spp.), and wheat Fusarium crown rot (*Fusarium* spp.), resulting in severe pre- and postharvest yield reductions (Alananbeh et al. 2024, Ghuffar et al. 2021, Zakaria 2024). At the same time, insects and pests significantly impact global food production across all stages of crop growth, harvest, and storage, leading to an estimated annual reduction of 18–20% of agricultural yield, equivalent to over US$ 470 billion (Souto et al. 2021). The black bean aphid (*Aphis fabae* Scopoli), a polyphagous pest infesting over 200 plant species, is particularly destructive to fava beans, with Algerian outbreaks causing up to 50% yield loss through direct damage (sap depletion, honeydew excretion, tissue deformation/gall formation) and indirect harm as a vector for more than 30 plant viruses (Benbelkhir et al. 2024). These impacts are compounded by rising costs of chemical control measures.

Conventional management of black bean aphids and fungal diseases depends on synthetic pesticides (neonicotinoids, pyrethroids, azoles, and strobilurins) for their broad-spectrum efficacy (Almogdad and Semaškienė 2021, Pandey and Rathore 2023, Pintye et al. 2024). However, their overuse endangers human health, ecosystems, and accelerates pesticide resistance (Hernández-Ceja et al. 2021, Li et al. 2024). Plant-derived biopesticides offer a sustainable alternative, combining low environmental persistence, minimal mammalian toxicity, and complex phytochemical profiles that limit resistance evolution. These attributes, alongside proven efficacy against diverse pests and pathogens, position botanical extracts as environmentally compatible tools for integrated pest management (Ahmed et al. 2020, Noureldeen et al. 2022).

Approximately 2.500 plant species from 235 botanical families show efficacy against pathogens and insects through their secondary metabolites (Ngegba et al. 2022). Notably, polyphenols serve dual protective functions, exhibiting both potent antioxidant capacity and enhanced defense mechanisms against biotic and abiotic stressors, thereby significantly improving plant stress tolerance (Hbika et al. 2022, Šamec et al., 2021).

Otospermum glabrum (Lag.) Willk. (Asteraceae) is an annual glabrous herb characterized by erect or ascending stems, 1-3 pinnatipartite leaves, and small corymbose inflorescences. The flowers feature white, tridentate ligules and black-bordered linear-obtuse bracts (Quezel and Santa 1962). As a member of the *Anthemideae* tribe, which includes bioactive genera like *Achillea*, *Artemisia*, and *Matricaria*, it likely shares their characteristic phytochemicals (phenolics, flavonoids, terpenoids, alkaloids, and coumarins) responsible for demonstrated antioxidant, antimicrobial, and insecticidal properties (El Mihyaoui et al. 2022, Kaczorová et al. 2021, Kursa et al. 2022, Silva-Beltran et al. 2023, Yang et al. 2024). This phytochemical similarity suggests that *O. glabrum* may possess comparable biological activities worthy of investigation.

To date, there is no existing documentation in the current literature regarding *O. glabrum*, aside from limited botanical and taxonomical reports. Therefore, this study aims to assess the total polyphenol and flavonoid content, explore the antioxidant and antifungal activities of *O. glabrum* extracts, and evaluate their aphicidal effects against *A. fabae*, known as the black bean aphid.

Despite the well-documented bioactivity of *Anthemideae* tribe members, *O. glabrum* remains pharmacologically unexplored, with only limited taxonomic descriptions available. This study therefore investigates the total polyphenol and flavonoid content, antioxidant and antifungal potential of its extracts, and aphicidal activity against *A. fabae*, a destructive pest of leguminous crops.

MATERIALS AND METHODS

Plant material

Aerial parts of *O. glabrum* were collected during the flowering period in April 2022 from the northern region of M'sila (35.8498° N, 4.5426° E), Algeria. The plant material was authenticated by Dr. Djamel Sarri, with a voucher specimen (OG2865QS28N) deposited in the herbarium of the Laboratory of Biology: Applications in Health and Environment at M'sila University. Following collection, the plant material was shade-dried at ambient temperature (25 ± 2 °C) and stored in paper bags until further use.

Plant extract preparation

The aqueous extract (AE) was prepared using a standardized decoction method (Ljubuncic et al. 2005). Briefly, plant

powder (50 g) was soaked in distilled water (500 ml) and heated to 90 °C for 15 min with constant stirring. The mixture was filtered through Whatman No. 1 filter paper, and the filtrate was concentrated at 40 °C using a drying oven. The final extract was stored at 4 °C until further use.

The ethyl acetate (EaA) and methanolic (ME) extracts were prepared by maceration (Mbarga et al. 2022). Plant powder (50 g) was soaked in 450 ml either methanol (Merck 99.9%) or ethyl acetate (Merck 99.8%) with continuous stirring for 24 hours, then filtered through Whatman No. 1 filter paper. The filtrates were concentrated under reduced pressure at 40 °C and stored at 4 °C until further use.

Total phenolic content (TPC)

Total phenolic content (TPC) in *O. glabrum* extracts was determined using a modified Folin-Ciocalteu reagent (FCR) method (Elbouzidi et al. 2023). Extract aliquots (100 µl) were mixed with 500 µl of 10% FCR, followed by addition of 400 µl of 7.5% Na_2CO_3 after 4 minutes. After 2 hours of incubation at room temperature, absorbance was measured at 765 nm against a blank, using a UV-Visible Spectrophotometer (CHIMADZU UV-1280 Multipurpose). A gallic acid standard curve was used to calculate results, expressed as micrograms of gallic acid equivalents per milligram of extract (µg GAE/mg).

Total flavonoid content (TFC)

Total flavonoid content (TFC) in *O. glabrum* extracts was determined using an aluminum chloride colorimetric assay modified from Madjitoloum Betoloum et al. (2018). Each extract aliquot (1 ml) was mixed with 1 ml of 2% $AlCl_3$ solution. After 10 minutes of incubation at room temperature, absorbance was measured at 415 nm against a blank. Results were calculated from a quercetin standard curve and expressed as micrograms of quercetin equivalents per milligram of extract (µg QE/mg).

Evaluation of the antioxidant activity

Total antioxidant capacity (TAC) assay

Total antioxidant capacity was determined using a modified phosphomolybdenum assay (Aazza et al. 2024) with ascorbic acid as standard. The reagent solution (0.6 M sulfuric acid, 4 mM ammonium molybdate, and 28 mM sodium phosphate) was prepared, and reaction mixtures containing 0.1 ml extract and 0.9 ml reagent solution were incubated at 95 °C for 90 min. After cooling at room temperature, absorbance was measured at 695 nm against a blank. Results were calculated from an ascorbic acid (AA) standard curve and expressed as micrograms of AA equivalents per milligram extract (µg AAE/mg).

Free radical scavenging assay

Free radical scavenging activity was determined using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay following Mokhtari et al. (2023) with some modification. Methanolic solutions of test extracts (1 ml) were mixed with 1 ml of 0.004% DPPH in methanol and incubated in the dark for 30 min at room temperature. Absorbance was measured at 517 nm against a DPPH solution control, with butylated hydroxytoluene (BHT) as positive control. Radical scavenging activity was calculated as:

$$I\ (\%) = [(A_c - A_t)/ A_c] \times 100$$

where A_c is the control absorbance and A_t is the test sample absorbance. The IC_{50} value (concentration yielding 50% inhibition) was determined from dose-response curves of inhibition percentage versus extract concentration.

β-carotene bleaching test

Antioxidant activity was evaluated using a β-carotene/ linoleic acid bleaching assay modified from Tabet Zatla et al. (2023). The β-carotene stock solution was prepared by dissolving 1 mg β-carotene in 5 ml chloroform with 25 µl linoleic acid and 200 mg Tween 40. After chloroform evaporation at 40 °C under vacuum, the residue was emulsified in 100 ml oxygen-saturated distilled water by vigorous shaking. For testing, 0.5 ml of methanolic extract solutions were mixed with 2 ml emulsion, with initial absorbance (t=0) measured immediately at 470 nm. Samples were then incubated at 50 °C for 120 min, followed by final absorbance measurement. Butylated hydroxytoluene (BHT) served as positive control. β-carotene bleaching inhibition was calculated as:

$$I\% = [(A_t - C_t / C_0 - C_t)] \times 100$$

where A_t is sample absorbance at 120 min, C_t is control absorbance at 120 min, and C_0 is control absorbance at t=0 min. The IC_{50} was determined from dose-response curves of inhibition percentage versus extract concentration.

Antifungal activity test

The fungal strains used in this study; *Aspergillus flavus*, *Aspergillus niger*, *Botrytis cinerea*, *Fusarium culmorum*, *Penicillium expansum*, and *Penicillium italicum*, were obtained from the department of microbiology & biochemistry's laboratory of microbiology, M'sila University, Algeria. These molds were previously isolated and identified by Hendel et al. (2024). They were cultivated on potato dextrose agar (PDA) slants and kept at 4 °C for storage until required.

Antifungal activity was evaluated on potato dextrose agar (PDA) using a modified agar incorporation method (Fatehi et al. 2021). Extracts (AE, ME, EaA) were dissolved in DMSO and incorporated into molten PDA at 10 mg/ml. Aliquots (20 ml) were dispensed into 90 mm Petri dishes and allowed to solidify. A 6 mm mycelial disc from the growing margin of 7-day-old fungal cultures was aseptically transferred to each plate center. Control plates contained DMSO without extract. After 7 days of incubation at 25 °C, fungal growth inhibition was calculated as:

$$I\% = [(D_C - D_T) / D_C] \times 100$$

where D_C is the control colony diameter and DT is the treated colony diameter.

Evaluation of the aphicidal activity

Adult black bean aphids and Vicia faba leaves used in this study were collected in April 2024 from an infested fava bean field in the Bordj Bou Arréridj area (36.0391° N, 4.8847° E), Algeria. Aphid-infested plant sections were carefully transferred to ventilated rearing cages and transported to the laboratory under controlled conditions to preserve colony integrity. To standardize bioassays, wingless adult aphids of uniform size were selectively isolated using a fine bristle brush to minimize physical stress. The selected individuals were subsequently transferred to Petri dishes for immediate bioassay procedures. Taxonomic identification was confirmed as *A. fabae* following Martin's (1983) morphological key, with voucher specimens deposited in the laboratory archive.

Toxicity test

Aphid bioassays were conducted in 90 mm Petri dishes under controlled laboratory conditions (25 ± 2 °C, 60 ± 20% RH, 16:8 L:D photoperiod). Four concentrations (5%, 10%, 20%, and 30% w/v) of AE and ME were prepared by dissolving *O. glabrum* extracts in distilled water. Following Salari et al. (2010), twenty-seven Petri dishes were prepared with three replicates per concentration. Fresh *Vicia faba* leaves were immersed in extract solutions for 10 seconds, air-dried, and placed on moist filter paper in each dish. Fifteen wingless adult aphids were then introduced per dish. Control treatments received distilled water only. Mortality was assessed at 24, 48, and 72 hours post-treatment, with aphids considered dead when showing no movement of legs or antennae.

Repellency test

Repellent activity of AE and ME was evaluated using a modified choice test (Moawad and Al-Barty 2011). Twenty-four Petri dishes (90 mm) were prepared with three replicates per concentration. Each dish contained filter paper divided into two equal sections. Pairs of surface-sterilized *V. faba* leaves were prepared - one leaf immersed in extract solution (5 min) and air-dried, while the other (untreated) served as control. Fifteen wingless adult aphids were released at the center of each dish. After 24 hours at 25 ± 2 °C, aphid distribution was recorded. Repellency percentage (RP) was calculated as:

$$RP\% = [(N_C - N_T) / (N_C + N_T)] \times 100$$

where N_C = number of aphids on control leaf and N_T = number on treated leaf.

Statistical analyses

For antioxidant and antifungal assays, all samples were analyzed in triplicate. Results are expressed as mean ± SD (n = 3). Data were analyzed by two-way ANOVA with Tukey's multiple comparisons test using GraphPad Prism 6.01 (GraphPad Software). Statistical significance was set at $p < 0.05$.

Corrected mortality (CM%) data were analyzed using generalized linear models (GLMs), followed by probit analysis to determine lethal concentration (LC_{50}) values with their confidence intervals. A multivariate analysis of variance (MANOVA) was performed to assess aphid mortality, with extract type, concentration, and exposure time as fixed factors and mortality as the response variable. Tukey's post hoc test was used for mean comparisons at a 5% significance level. All statistical analyses were conducted using R Studio (version 1.2.5019) with R software (version 3.6.1).

RESULTS

Extraction yield

In this study, three extraction methods were employed: aqueous extraction by decoction yielded 23.91 ± 1.43% (w/w), while methanolic and ethyl acetate extractions by maceration yielded 17.89 ± 1.82% and 6.53 ± 0.76% (w/w), respectively.

Polyphenolics and antioxidant activity

Table 1 presents the total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity profiles of the plant extracts. Spectrophotometric analysis revealed significant differences in phytochemical composition, with ethyl acetate extract (EaE) showing the highest TPC (57.60 ± 0.17 µg GAE/mg) and TFC (49.46 ± 0.66 µg QE/mg), followed by methanolic extract (ME) and aqueous extract (AE) ($p < 0.05$).

The antioxidant properties of *O. glabrum* extracts, evaluated by TAC, DPPH radical scavenging, and β-carotene/linoleic acid assays, are summarized in Table 1. The AE exhibited the highest TAC value (252.60 ± 0.20 µg AAE/mg), followed closely by the EaE (249.10 ± 0.81 µg AAE/mg), while the ME recorded the lowest TAC (154.92 ± 1.06 µg AAE/mg). DPPH radical scavenging assays revealed ME as the most potent (IC_{50} = 56.05 ± 0.03 µg/ml), though three-fold less active than the BHT standard (21.69 ± 0.04 µg/ml). Both AE and EaE showed minimal DPPH scavenging (IC_{50} > 200 µg/ml). In the β-carotene/linoleic acid system, all three extracts demonstrated significant inhibition of linoleic acid oxidation at 500 µg/ml. The ME achieved complete inhibition (100%, IC_{50} = 7.27 ± 0.95 µg/ml), comparable to BHT, with no significant difference ($p < 0.05$) compared to the standard, while the AE and EaE exhibited inhibition rates of 93.42% and 89.26%, with corresponding IC50 values of 63.67 ± 3.92 µg/ml and 26.66 ± 2.70 µg/ml, respectively.

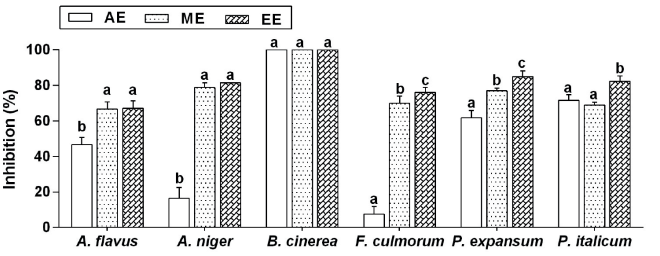

Figure 1. Inhibitory effect of the AE, ME, and EE of *Otospermum glabrum* on the tested molds. No significant differences are indicated by the same letters on each mold column (Tukey's multiple comparisons test, $p<0.05$; data are means (n=3) ± SD)

Evaluation of the aphicidal activity

Toxicity assays against *A. fabae* revealed significant concentration- and time-dependent mortality effects for *O. glabrum* extracts (Table 2). Both extract concentration ($F(3.32) = 15.601$, $p = 0.000^{***}$) and exposure duration ($F(3.32) = 71.390$, $p = 0.0000^{***}$) significantly influenced aphid mortality. The methanolic extract (ME) demonstrated superior efficacy, achieving 100% mortality at 30% concentration (72-h LC_{50} = 51.02%), while the aqueous extract (AE) showed 86.24% mortality (72-h LC_{50} = 46.77%). Lower concentrations (5-20%) exhibited progressive mortality increases: ME (31.11-72.49%) and AE (33.33-78.09%) across 24-72 h exposure periods.

Table 1. Polyphenolic and flavonoid contents and antioxidant activity of *Otospermum glabrum* extracts as measured by multiple assays

Extract / Standard	Test				
	Polyphenols (µg GAE/mg)	**Flavonoids (µg QE/mg)**	**TAC (µg AAE/mg)**	**DPPH (IC_{50}, µg/ml)**	**β-carotene (IC_{50}, µg/ml)**
ME	42.80 ± 0.56	17.61 ± 0.10	154.92 ± 1.06	56.05 ± 0.03	7.27 ± 0.95[a*]
EaE	57.60 ± 0.17	49.46 ± 0.66	249.10 ± 0.81	241.23 ± 0.06	63.67 ± 3.92
AE	19.39 ± 0.16	7.23 ± 0.12	252.60 ± 0.20	267.69 ± 0.47	26.66 ± 2.70
BHT	-	-	-	21.69 ± 0.04	4.73 ± 0.40[a]

*Values with the same superscript letter are not statistically different according to the two-way analysis of variance (ANOVA) followed by Tukey's multiple comparisons test, $p<0.05$. Values are means (n = 3) ± SD

Evaluation of the antifungal activity

The antifungal activity of *O. glabrum* extracts (10 mg/ml) was evaluated by measuring fungal growth inhibition. All extracts demonstrated significant antifungal effects against the tested strains (Figure 1), with complete inhibition of *B. cinerea* growth observed for all treatments. Ethyl acetate extract (EaE) showed the strongest overall inhibition, followed by methanolic extract (ME), with both maintaining >65% inhibition across all fungi. Notably, EaE and ME exhibited statistically similar efficacy ($P < 0.05$) against *A. flavus* and *A. niger*. In contrast, aqueous extract (AE) displayed the weakest activity (7.56-71.56% inhibition), except against *P. italicum*, where its performance slightly exceeded ME ($p < 0.05$).

Repellency test

Repellent activity of *O. glabrum* extracts against *A. fabae* showed concentration-dependent effects (Table 3). Both extract type ($F(1.16) = 4.5$, $p = 0.048^{*}$) and concentration ($F(3.16) = 5.19$, $p = 0.01071$) significantly influenced repellency. The methanolic extract (ME) exhibited stronger

Table 2. Lethal concentrations of *Otospermum glabrum* extract against Aphis fabae aphid population following 72 h exposure

Extract	Exposure time	Concentration (%)	Corrected mortality (%)*	LC_{50} (%)	95% Confidence Interval	Slope ± SE	χ^2
AE	24 h	5	33.33±0.00^{lk}	49.73±0.29	46.75–55.46	1.4 ± 0.2	2.1
		10	51.11±2.22^{jihg}				
		20	53.33l±3.84^{ihgf}				
		30	55.56±4.44^{lihgfe}				
	48 h	5	41.75±3.21^{lkj}	46.94±2.40	35.45–57.53	1.5 ± 0.3	2.4
		10	53.49±2.06^{lihgf}				
		20	58.10±4.22^{lihgfe}				
		30	65.08±0.79^{hgfed}				
	72 h	5	61.31±7.92^{lihgfe}	46.77±6.03	45.77–76.83	1.2 ± 0.3	2.6
		10	69.93f±3.85^{edc}				
		20	78.09±3.48^{dcb}				
		30	86.24±3.13^{b}				
ME	24 h	5	31.11±0.00^{l}	49.74±0.25	45.53–73.24	1.3 ± 0.2	2.3
		10	31.11±2.22^{l}				
		20	42.22±5.87^{lkj}				
		30	68.89±2.22^{gfedc}				
	48 h	5	44.29±2.97^{lkji}	48.37±2.06	37.67–59.77	1.4 ± 0.3	2.1
		10	48.73±3.09^{kjih}				
		20	48.57±5.71^{kjih}				
		30	83.65±2.55cb				
	72 h	5	59.21±5.01^{lihgfe}	51.02±0.01	49.37–69.03	1.1 ± 0.2	2.5
		10	64.80±2.29^{hgfed}				
		20	72.49±6.27^{edcb}				
		30	100±0.00^{a}				
F-(1.12)=0.231. P=.63		F-(2.12)=124.61 P=.0.00000		F- (3.12)=71.30 P=.0.00000			

*Values are presented as mean ± SE (n=3). significant differences were determined at P ≤ 0.05; different superscript letters within a column indicate statistically significant differences at P < 0.05

Table 3. Repellent activity of *Otospermum glabrum* extract against *Aphis fabae* populations

Plant extracts	Concentration (%)	RP (%)*	Class
AE	5	12.50±00.00^{b}	I
	10	12.50±00.00^{b}	I
	20	31.94±10.84^{ab}	II
	30	31.94±10.84^{ab}	II
ME	5	26.38±06.94^{ab}	II
	10	19.44±06.94^{ab}	I
	20	38.88±05.55^{ab}	II
	30	48.98±08.76^{a}	III
F-value (1. 16) =4.5. P=.048		F-value (3. 16)=5.19.P=.01071	

*RP - Repellency percentage (mean ± SE, n = 3). Different superscript letters within columns indicate statistically significant differences (p < 0.05)

repellent effects (26.38-48.98%) compared to the aqueous extract (AE; 12.50-31.94%), with efficacy increasing proportionally to concentration.

DISCUSSION

Extraction yields followed the polarity-dependent trend: ethyl acetate extract (EaE) < methanolic extract (ME) < aqueous extract (AE), consistent with the higher efficiency of polar solvents for phytochemical extraction. This pattern reflects the differential solubility of plant metabolites, where solvent polarity critically influences extraction efficiency (Molole et al. 2022). The superior yield of AE likely results from both the high polarity of water and the elevated temperature during decoction, which enhances solubility of polar compounds including flavonoids, alkaloids, and polysaccharides (Kumar et al. 2023). Similar polarity-yield relationships have been documented in related Anthemideae genera; *Achillea* (Toplan et al. 2022) and *Artemisia* (Trifan et al. 2022), confirming our observations.

Total phenolic (TPC) and flavonoid (TFC) contents exhibited a consistent solvent polarity-dependent trend: aqueous < methanolic < ethyl acetate extracts. This pattern reflects the preferential solubility of polyphenolic compounds - including phenolic acids, terpenes, and methoxylated flavonoid aglycones - in less polar solvents (Palaiogiannis et al. 2023). The aqueous extract's lower yields may result from both the limited solubility of non-polar phenolics in water and potential thermal degradation during decoction (Lezoul et al. 2020). These findings align with previous reports on Algerian *Matricaria chamomilla* (Khennouf et al. 2013) and *Achillea* species (Kaczorová et al. 2021), where chloroform and ethyl acetate consistently outperformed polar solvents in extracting polyphenols, confirming that medium-polarity solvents optimally recover these bioactive compounds. Comparative analysis reveals superior polyphenolic content in *O. glabrum* relative to related species. Our TPC and TFC values significantly exceeded those reported for *Achillea* species (TPC: 16.34-27.48 µg GAE/mg; TFC: 11.31-27.13 µg QE/mg) (Mehmood et al. 2022) and approached the highest levels documented in *Artemisia* species (methanol extracts: 106.34 µg GAE/g in *A. vulgaris*; 47.74 µg RE/mg in *A. annua*) (Trifan et al. 2022). Notably, our extracts consistently outperformed the lowest-yielding chloroform extracts of *A. absinthium* (TPC: 5.78 µg GAE/g; TFC: 0.37 µg RE/mg). These findings position *O. glabrum* as a particularly rich source of bioactive polyphenols, with significant potential for biologically protective applications.

The antioxidant results revealed an inverse relationship between *O. glabrum*'s total phenolic/flavonoid content (TPC/TFC) and total antioxidant capacity (TAC), with the aqueous extract (AE) showing the highest TAC despite lower TPC/TFC levels. This apparent discordance results from three key factors: the presence of non-phenolic antioxidants (e.g., carotenoids, tocopherols) not detected by TPC assays, structural efficacy of specific compounds that disproportionately contribute to antioxidant activity, and synergistic interactions between phytochemicals that enhance overall activity. These findings align with reports in *Artemisia* species (Guenane et al. 2024, Trifan et al. 2022), confirming that antioxidant potential cannot be predicted by polyphenolic content alone. Notably, *O. glabrum*'s TAC (up to 252.60 µg AAE/mg) exceeded values reported for related species like *Achillea coarctata* (226.82 µg AAE/mg) and *Matricaria chamomilla* (100–124 µg AAE/mg), highlighting its exceptional antioxidant profile (Albayrak and Silahtarlıoğlu, 2019).

The DPPH radical scavenging results revealed that the EaE of *O. glabrum*, despite containing the highest levels of TPC and TFC, exhibited significantly lower antioxidant activity compared to the ME. This apparent contradiction stems from the structural specificity of DPPH radicals, which preferentially react with flavonoids containing hydroxyl groups on the β-ring and polyhydroxy aromatic acids (Mammeri et al. 2022), rather than responding to overall phenolic concentration. The superior activity of the ME can be attributed to its greater polarity, which enhances extraction of hydroxyl-rich phenolic compounds that are particularly effective in radical neutralization (Kaczorová et al. 2021). These findings are consistent with studies on *Achillea* species (Kaczorová et al. 2021, Şabanoğlu et al. 2019) and *Artemisia* species (IC_{50}: 107.2-227 µg/ml) (Ranjbar et al. 2020), confirming that antioxidant efficacy depends more on molecular structure than total polyphenol content. Notably, *O. glabrum*'s ME (IC_{50} = 56.05 µg/ml) showed stronger radical scavenging activity than most reported values for related Anthemideae species, including various populations of *Matricaria chamomilla* (IC_{50}: 19.23-73.35 µg/ml) (Hassanpour et al. 2020), highlighting its exceptional antioxidant potential despite having only moderate TPC levels. This pattern underscores the importance of considering both chemical composition and specific antioxidant mechanisms when evaluating plant extracts for their radical scavenging capacity.

The β-carotene bleaching assay revealed that *O. glabrum*'s EaE extract, despite having the highest TPC/TFC levels, showed the weakest antioxidant activity, underscoring that polyphenols play only a limited role in preventing lipid peroxidation (Faraone et al. 2018). This paradox reflects the system's dependence on non-phenolic antioxidants (carotenoids, tocopherols) that more effectively quench lipid-derived radicals (Othman et al. 2014), as previously

observed in *Achillea* species (Agar et al. 2015, Gharibi et al. 2013). Notably, *O. glabrum* extracts demonstrated superior inhibition of linoleic acid oxidation compared to related Anthemideae species - exceeding the 30-90% range reported for *Achillea* (Gharibi et al. 2015) and matching or surpassing *Artemisia* species (*A. campestris*: 88.03%; *A. herba-alba*: 67.56%; *A. absinthium*: 48.7%) (Bouguerra et al. 2020, Mourad et al. 2018). These results position *O. glabrum* among the most effective antioxidant species in the tribe, while confirming that lipid peroxidation inhibition depends on specific antioxidant profiles rather than total phenolic content.

The antifungal activity of *O. glabrum* extracts showed a strong positive correlation with their total phenolic and flavonoid content, consistent with the established antimicrobial properties of polyphenolic compounds (Lagnika et al. 2016). This relationship explains the observed variability in efficacy across extracts, where ethyl acetate extracts with higher TPC/TFC demonstrated superior antifungal activity compared to aqueous extracts. The differential sensitivity of fungal species to specific secondary metabolites (Salem et al. 2019) and the polarity-dependent extraction efficiency of bioactive compounds further account for these variations. Our findings align with current literature demonstrating that organic extracts typically outperform aqueous extracts in antimicrobial activity (Rahim et al. 2023), and moderately polar solvents optimally extract antimicrobial phytochemicals (Lagnika et al. 2016).

The aqueous extract (AE) showed unexpectedly high activity against *Penicillium italicum*, potentially due to the fungus' sensitivity to water-soluble compounds, and synergistic effects of non-phenolic phytochemicals (alkaloids, glycosides, terpenoids) with demonstrated antifungal properties (Chioma et al. 2021, Onanuga and Oloyede 2022). This species-specific response likely reflects differences in fungal cell wall composition and metabolic pathways that influence susceptibility to particular phytochemical structures (Silva-Beltran et al. 2023).

Otospermum glabrum extracts exhibited superior antifungal activity compared to related Anthemideae species. While *Matricaria aurea* showed moderate inhibition (31.48-53.44%) against *Aspergillus* spp. (Rizwana et al. 2016), and *Artemisia campestris* methanol extract achieved 51.96-56.47% inhibition against *Botrytis cinerea* and *P. expansum* (Hendel et al. 2021), *O. glabrum* demonstrated consistently stronger efficacy. The variable performance of *Achillea* and *Artemisia* species (18-63.82% inhibition) (Andreu et al. 2018, Kursa et al. 2022, Salem et al. 2019) further highlights *O. glabrum*'s potential as a promising candidate for the development of new biofungicides, particularly given the economic importance of the target pathogens.

The aphicidal activity of *O. glabrum* extracts arises from its rich range of secondary metabolites, including phenolics, flavonoids, terpenoids, and alkaloids (Li et al. 2024, Noureldeen et al. 2022). These bioactive compounds disrupt key physiological processes in aphids; deterring feeding, impairing development, and reducing reproductive capacity (Lebbal et al. 2023). Our findings align with documented efficacy of plant extracts against multiple aphid species (*Aphis fabae*, *Macrosiphum rosae*, *Brevicoryne brassicae*, *Aphis craccivora*) (Abdel-Rahman et al. 2019, Ahmed et al. 2020, Thakshila et al. 2022).

Otospermum glabrum demonstrated particularly strong insecticidal effects against *A. fabae*, with methanolic extract (ME) achieving 100% mortality at 72 h (highest concentration) versus 80% for aqueous extract (AE). ME also showed superior repellency (48.98% maximum) compared to AE (31.94% maximum). This differential bioactivity reflects variations in extract composition, where ME's lower polarity likely enhanced extraction of non-polar bioactive compounds with greater aphid toxicity.

Comparative analysis reveals differential aphicidal efficacy among Anthemideae species. While *Artemisia judaica* ethanolic extract achieved 100% *Aphis fabae* mortality within 2 hours at 12.5 mg/ml (Acheuk et al. 2017), O. glabrum required higher concentrations and longer exposure (72 h). Conversely, *Matricaria chamomilla* aqueous extracts showed only 35% mortality after 120 h (Biniaś and Gospodarek 2017), demonstrating *O. glabrum*'s intermediate potency. Against other aphid species, *Achillea millefolium* essential oil exhibited superior contact toxicity (LC_{50} 0.34%) and repellency (58.1%) to *Myzus persicae* (Czerniewicz et al. 2018), while *Artemisia* spp. ethyl acetate extracts showed complete *Macrosiphoniella sanborni* control within 7 days (Yang et al. 2024). *O. glabrum* displayed faster toxicity but weaker repellency than these counterparts, suggesting distinct mode-of-action profiles. Beyond aphids, *Artemisia absinthium* methanol extract caused 100% *Sitophilus oryzae* mortality within 24 h (Dane et al. 2016), whereas O. glabrum required 72 h for complete *A. fabae* control. However, *O. glabrum* achieved comparable efficacy at lower concentrations than *A. absinthium* against *Tribolium castaneum* (93.3% mortality at 95 mg/ml; Naimi et al. 2025). These variations likely reflect species-specific susceptibility and differential phytochemical bioavailability.

While this study provides the first evidence of *O. glabrum*'s bioactivity, its laboratory-scale design using crude extracts

limits field relevance and mechanistic understanding. Future work should employ bioassay-guided fractionation (HPLC/LC-MS) to isolate active compounds, validate efficacy in field trials, and expand testing to diverse pests/pathogens. Investigating synergies with existing biocontrol agents would further support its integration into sustainable pest management systems.

This study provides the first comprehensive evaluation of *Otospermum glabrum* as a source of bioprotective agents, demonstrating significant antioxidant, antifungal, and aphicidal activities. The ethyl acetate extract showed superior phenolic and flavonoid contents, correlating with enhanced bioactivity, while the methanolic extract exhibited the strongest aphid toxicity. These findings highlight the influence of extraction solvents on phytochemical recovery and biological efficacy. As a novel botanical resource, *O. glabrum* shows exceptional potential for developing multi-target, eco-friendly biopesticides. Future research should focus on isolating active compounds through bioassay-guided fractionation and validating field efficacy to facilitate its integration into sustainable crop protection strategies that address both pest management and food security challenges.

ACKNOWLEDGEMENTS

This work was supported by the DGRSDT, university of M'sila (PRFU, Projets de Recherche Formation Universitaire) [grant number D01N01UN280120220001].

Author's Contributions

Authors declare the contribution of the authors is equal.

Statement of Conflict of Interest

The author declared no conflict of interest.

ÖZET

Tarımsal zararlı yönetiminde sentetik kimyasallar yerine bitki bazlı biyopestisitlerin benimsenmesi, güvenlikleri ve ekolojik faydaları nedeniyle giderek artan bir ilgi çekmektedir. Bu doğal bileşiklerin birçoğu güçlü antifungal aktivite göstererek gıda kaynaklı mantar kontaminasyonunu ve ilişkili mikotoksinleri azaltmaktadır. Bu çalışmada, *Otospermum glabrum*'un (Asteraceae) toprak üstü kısımlarından elde edilen ekstraktların antioksidan, antifungal ve afisidal potansiyeli değerlendirilmiştir. Üç ekstrakt –etil asetat, metanolik ve sulu– toplam polifenolik ve flavonoid içerikleri, antioksidan aktiviteleri (DPPH radikal süpürme, β-karoten ağartma ve toplam antioksidan kapasitesi), altı hasat sonrası ve bitki fungal patojenine karşı antifungal etkileri ve bakla yaprakbitine (*Aphis fabae* Scop.) karşı afisidal aktiviteleri açısından değerlendirilmiştir. Etil asetat özütü (EaE), test edilen özütler arasında en yüksek polifenol (57.60 ± 0.17 µg GAE/mg) ve flavinoid (49.46 ± 0.66 µg QE/mg) seviyesine sahipken; metanolik özüt (ME), en yüksek DPPH temizleme aktivitesi (IC50= 56.05±0.03 µg/ml) ve β-karoten ağartmasını önlemede en yüksek etkinliğini göstererek BHT'ninkine eşdeğer bir inhibitör aktivitesine ulaşmıştır. Sulu özüt ve etil asetat özütü, en yüksek toplam antioksidan kapasitesini göstermiştir (sırasıyla 252.60±0.20 µg AAE/mg ve 249.10±0.81 AAE/mg). Antifungal testlerine göre etil asetat özütü ve metanolik özütü tüm test edilen funguslara karşı %65'i geçen inhibisyon yüzdeleri (IP) ile en belirgin etkiyi ortaya koymuştur. Ek olarak, %30 konsantrasyonundaki metanolik ekstrakt, 72 saat sonra *A. fabae*'de %100 ölüme neden olmuş ve önemli bir kovucu etki (%48.98 ± 8.76) göstermiştir. Bu bulgular, *O. glabrum*'un entegre zararlı yönetimi için umut verici doğal bir biyopestisit kaynağı olduğunu göstermektedir.

Anahtar kelimeler: *Otospermum glabrum*, polifenoller, antioksidan aktivite, antifungal aktivite, afisidal aktivite

REFERENCES

Aazza S., El-Guendouz S., Miguel M.G., 2024. Antioxidant and α-amylase inhibition activities of six plants used in the management of diabetes in Morocco. Letters in Applied NanoBioScience, 13 (1), 17. https://doi.org/10.33263/LIANBS131.017

Abdel-Rahman R.S., Ismail I.A., Mohamed T.A., Hegazy M.E.F., Abdelshafeek K.A., 2019. Laboratory and field evaluation of certain wild plant extracts against *Aphis fabae* Scop. (Homoptera: Aphididae) and its predators. Bulletin of the National Research Centre, 43, 44. https://doi.org/10.1186/s42269-019-0084-z

Acheuk F., Lakhdari W., Abdellaoui K., Belaid M., Allouane R., Halouane F., 2017. Phytochemical study and bioinsecticidal effect of the crude ethanolic extract of the Algerian plant *Artemisia judaica* L. (*Asteraceae*) against the black bean aphid, *Aphis fabae* Scop. The Journal Agriculture and Forestry, 63 (1), 95-104. https://doi.org/10.17707/AgricultForest.63.1.11

Albayrak S., Silahtarlıoğlu N., 2019. Determination of biological activities of essential oil and extract obtained from *Achillea coarctata* Poir. Oriental Pharmacy and Experimental Medicine, 19, 135-146. https://doi.org/10.1007/s13596-019-00378-w.

Agar O.T., Dikmen M., Ozturk N., Yilmaz M.A., Temel H., Turkmenoglu F.P., 2015. Comparative studies on phenolic composition, antioxidant, wound healing and cytotoxic activities of selected *Achillea* L. species growing in Turkey. Molecules, 20 (10), 17976–18000. https://doi.org/10.3390/molecules201017976

Ahmed M., Peiwen Q., Gu Z., Liu Y., Sikandar A., Hussain D., Javeed A., Shafi J., Iqbal M.F., An R., Guo H., Du Y., Wang W., Zhang Y., Ji M., 2020. Insecticidal activity and biochemical composition of *Citrullus colocynthis*, *Cannabis indica*, and *Artemisia argyi* extracts against cabbage aphid (*Brevicoryne brassicae* L.). Scientific Reports, 10, 522. https://doi.org/10.1038/s41598-019-57092-5

Alananbeh K.M., Al-Abdallat A., Al-Hiary H., 2024. First report of *Fusarium culmorum* causing crown rot on wheat in Jordan. Plant Disease, 108 (3), 799. https://doi.org/10.1094/PDIS-08-23-1714-PDN

Almogdad M., Semaškienė R., 2021. The occurrence and control of black bean aphid (*Aphis fabae* Scop.) in broad bean. Zemdirbyste-Agriculture 108 (2), 165-172. https://doi.org/10.13080/z-a.2021.108.022

Andreu V., Levert A., Amiot A., Cousin A., Aveline N., Bertrand C., 2018. Chemical composition and antifungal activity of plant extracts traditionally used in organic and biodynamic farming. Environmental Science and Pollution Research International, 25 (30), 16987–17000. https://doi.org/10.1007/s11356-018-1320-z

Benbelkhir F.Z., Allali K., Benadjila A., Goudjal Y., Medjekal S., Zamoum M., 2024. Development of bioinsecticide based on *Streptomyces griseoflavus* PAL114 for control of black bean aphids *Aphis fabae*. Biocontrol Science and Technology, 34 (8), 736–753. https://doi.org/10.1080/09583157.2024.2373477

Biniaś B., Gospodarek J., 2017. Effect of water extract from chamomile on black bean aphid and Colorado potato beetle. Journal of Ecological Engineering, 18 (3), 118–124. https://doi.org/10.12911/22998993/69363

Bouguerra A., Djebili S., Zouaoui N., Barkat M., 2020. Evaluation of phenolic contents and antioxidant activities of some medicinal plants growing in Algerian Aurès Mountains. Acta Scientifica Naturalis, 7 (2), 15–30. https://doi.org/10.2478/asn-2020-0017

Chioma N., Christie O., Nathaniel O., Aqib F., 2021. Phytochemical analysis and in vitro screening of antifungal activity of *Jatropha multifida*, *Euphorbia hirta*, *Occimum gratissimum* and *Mitracarpus scaber* leaves extract. GSC Biological and Pharmaceutical Sciences, 14 (3), 098-112.

Czerniewicz P., Chrzanowski G., Sprawka I., and Sytykiewicz H., 2018. Aphicidal activity of selected Asteraceae essential oils and their effect on enzyme activities of the green peach aphid, *Myzus persicae* (Sulzer). Pesticide Biochemistry and Physiology, 145, 84-92.

https://doi.org/10.1016/j.pestbp.2018.01.010

Dane Y., Mouhouche F., Canela-Garayoa R., Delpino-Rius A., 2016. Phytochemical analysis of methanolic extracts of *Artemisia absinthium* L. (Asteraceae), *Juniperus phoenicea* L., and *Tetraclinis articulata* (Cupressaceae) and evaluation of their biological activity for stored grain protection. Arabian Journal for Science and Engineering, 41, 2147–2158. https://doi.org/10.1007/s13369-015-1977-2

Deresa E.M., Diriba T.F., 2023. Phytochemicals as alternative fungicides for controlling plant diseases: a comprehensive review of their efficacy, commercial representatives, advantages, challenges for adoption, and possible solutions. Heliyon, 9 (3), e13810. https://doi.org/10.1016/j.heliyon.2023.e13810

El Mihyaoui A., Esteves da Silva J.C.G., Charfi S., Candela Castillo M.E., Lamarti A., Arnao M.B., 2022. Chamomile (*Matricaria chamomilla* L.): a review of ethnomedicinal use, phytochemistry, and pharmacological uses. Life, 12 (4), 479. https://doi.org/10.3390/life12040479

Elbouzidi A., Taibi M., Ouassou H., Ouahhoud S., Ou-Yahia D., Loukili E.H., Aherkou M., Mansouri F., Bencheikh N., Laaraj S., Bellaouchi R., Saalaoui E., Elfazazi K., Berrichi A., Abid M., Addi, M., 2023. Exploring the multi-faceted potential of carob (*Ceratonia siliqua* var. Rahma) leaves from Morocco: a comprehensive analysis of polyphenols profile, antimicrobial activity, cytotoxicity against breast cancer cell lines, and genotoxicity. Pharmaceuticals, 16 (6), 840. https://doi.org/10.3390/ph16060840

Faraone I., Rai D.K., Chiummiento L., Fernandez E., Choudhary A., Prinzo F., Milella L., 2018. Antioxidant activity and phytochemical characterization of *Senecio clivicolus* Wedd. Molecules, 23 (10), 2497. https://doi.org/10.3390/molecules23102497

Fatehi N., Benmehdi H., Allali H., Sahel N., Oulednecir N., 2021. Evidence-based antifungal potential of some traditional medicinal plants from the Bechar region (Southwest Algeria). Indian Journal of Natural Products and Resources, 12 (1), 68–73. doi:10.56042/ijnpr.v12i1.23936

Gharibi S., Sayed Tabatabaei B.E., Saeidi G., 2015. Comparison of essential oil composition, flavonoid content and antioxidant activity in eight Achillea species. Journal of Essential Oil Bearing Plants, 18 (6), 1382–1394. https://doi.org/10.1080/0972060X.2014.981600

Gharibi S., Sayed Tabatabaei B.E., Saeidi G., Goli S.A.H., Talebi M., 2013. Total phenolic content and antioxidant activity of three Iranian endemic Achillea species. Industrial Crops and Products, 50, 154–158. https://doi.org/10.1016/j.indcrop.2013.07.038

Ghuffar S., Irshad G., Naz F., Khan M.A., 2021. Studies of *Penicillium* species associated with blue mold disease of grapes and management through plant essential oils as non-hazardous botanical fungicides. Green Processing and Synthesis, 10 (1), 21–36. https://doi.org/10.1515/gps-2021-0007

Guenane H., Rezzoug M., Bakchiche B., Cheraif K., Mohamed A.S., El-Shazly M.A.M., 2024. Antioxidant properties and mineral contents of different solvent extracts of some medicinal plants cultivated in Algeria. Tropical Journal of Natural Product Research, 8 (1), 5987–5991. https://doi.org/10.26538/tjnpr/v8i1.39

Hassanpour H., Niknam V., Ahmadi-Sakha S., Haddadi B., 2020. Antioxidant activity and flavonoid content of *Matricaria chamomilla* extracts from different populations of Iran. Journal of Botanical Research, 2 (2), 8-13. https://doi.org/10.30564/jrb.v2i2.1909

Hbika A., Daoudi N.E., Bouyanzer A., Bouhrim M., Mohti H., Loukili E.H., Mechchate H., Al-Salahi R., Nasr F.A., Bnouham M., Zaid A., 2022. *Artemisia absinthium* L. aqueous and ethyl acetate extracts: antioxidant effect and potential activity *in vitro* and *in vivo* against pancreatic α-amylase and intestinal α-glucosidase. Pharmaceutics, 14 (3), 481. https://doi.org/10.3390/pharmaceutics14030481

Hendel N., Sarri D., Sarri M., Selloum M., Boussakra F., Driche O., 2021. Screening for in vitro antioxidant activity and antifungal effect of *Artemisia campestris* L. International Journal of Agriculture, Environment and Food Sciences, 5 (3), 251–259. https://doi.org/10.31015/jaefs.2021.3.1

Hendel N., Sarri D., Sarri M., Napoli E., Palumbo Piccionello A., Ruberto G., 2024. Phytochemical analysis and antioxidant and antifungal activities of powders, methanol extracts, and essential oils from *Rosmarinus officinalis* L. and *Thymus ciliatus* Desf. Benth. International Journal of Molecular Sciences, 25 (14), 7989. doi: 10.3390/ijms25147989

Hernández-Ceja A., Loeza-Lara P.D., Espinosa-García F.J., García-Rodríguez Y.M., Medina-Medrano J.R., Gutiérrez-Hernández G.F., Ceja-Torres L.F., 2021. *In vitro* antifungal activity of plant extracts on pathogenic fungi of blueberry (*Vaccinium* sp.). Plants, 10 (5), 852. https://doi.org/10.3390/plants10050852

Kaczorová D., Karalija E., Dahija S., Bešta-Gajević R., Parić A., Čavar Zeljković S., 2021. Influence of extraction solvent on the phenolic profile and bioactivity of two *Achillea* species. Molecules, 26 (6), 1601. https://doi.org/10.3390/molecules26061601

Khennouf S., Benchiekh D., Djidel S., Dahamna S., Amira S., Charef N., Baghiani A., Harzallah D., Arrar L., 2013. Polyphenols and antioxidant properties of extracts from *Mentha pulegium* L. and *Matricaria chamomilla* L. Pharmacognosy Communications, 3 (2), 35–40. https://doi.org/10.5530/pc.2013.2.8

Kumar A., Nirmal P., Kumar M., Jose A., Tomer V., Oz E., Proestos C., Zeng M., Elobeid T., Sneha K., Oz F., 2023. Major phytochemicals: recent advances in health benefits and extraction method. Molecules, 28 (2), 887. https://doi.org/10.3390/molecules28020887

Kursa W., Jamiołkowska A., Wyrostek J., Kowalski R., 2022. Antifungal effect of plant extracts on the growth of the cereal pathogen *Fusarium* spp.—an *in vitro* study. Agronomy, 12 (2), 3204. https://doi.org/10.3390/agronomy12123204

Lagnika L., Amoussa A.M.O., Adjileye R.A.A., Laleye A., Sanni A., 2016. Antimicrobial, antioxidant, toxicity and phytochemical assessment of extracts from *Acmella uliginosa*, a leafy vegetable consumed in Bénin, West Africa. BMC Complementary and Alternative Medicine, 16, 34. https://doi.org/10.1186/s12906-016-1014-3

Lebbal S., Benhizia T., Djebaili S., Bouzidi C., Ghassir H., Rahal K., Zeraib A., 2023. Aphicidal activity screening of plant extracts from *Pistacia lentiscus* (Anacardiaceae). Entomologia Hellenica, 32 (2), 12–19. https://doi.org/10.12681/entomologia.35414

Lezoul N.E.H., Belkadi M., Habibi F., Guillén F., 2020. Extraction processes with several solvents on total bioactive compounds in different organs of three medicinal plants. Molecules, 25 (20), 4672. https://doi.org/10.3390/molecules25204672

Li H., Zhao R., Pan Y., Tian H., Chen W., 2024. Insecticidal activity of *Ageratina adenophora* (Asteraceae) extract against *Limax maximus* (Mollusca, Limacidae) at different developmental stages and its chemical constituent analysis. PLOS One, 19 (4), e0298668. https://doi.org/10.1371/journal.pone.0298668

Ljubuncic P., Song H., Cogan U., Azaizeh H., Bomzon A., 2005. The effects of aqueous extracts prepared from the leaves of *Pistacia lentiscus* in experimental liver disease. Journal of Ethnopharmacology, 100 (1-2), 198–204. https://doi.org/10.1016/j.jep.2005.03.006

Mammeri A., Bendif H., Bensouici C., Benslama A., Rebas K., Bouasla A., Rebaia I., Souilah N., Miara M.D., 2022. Total phenolic contents, in vitro antioxidant activity, enzymes inhibition, and anti-inflammatory effect of the selective extracts from the Algerian *Lavandula multifida*. Acta Pharmaceutica Sciencia, 60 (1), 1–15. https://doi.org/10.23893/1307-2080.APS.6001

Martin J.H. (1983). The identification of common aphid pests of tropical agriculture. Tropical Pest Management, 29 (4), 395–411. https://doi.org/10.1080/09670878309370834

Mbarga M.J.A., Podoprigora I.V., Anyutoulou K.L.D., Kezimana P., Smolyakova L.A., Tene M.H., Rehailia M., Yashina N.V., Smirnova I.P., Manga I.A.M., Das M.S., 2022. Antimicrobial and antibiotic-resistance reversal activity of some medicinal plants from Cameroon against selected resistant and non-resistant uropathogenic bacteria. Frontiers in Bioscience (Elite Ed), 14 (4), 25. https://doi.org/10.31083/j.fbe1404025

Mehmood A., Javid S., Khan M.F., Ahmad K.S., Mustafa A., 2022. *In vitro* total phenolics, total flavonoids, antioxidant and antibacterial activities of selected medicinal plants using different solvent systems. BMC Chemistry, 16, 64. https://doi.org/10.1186/s13065-022-00858-2

Moawad S.S., Al-Barty A.M.F., 2011. Evaluation of some medicinal and ornamental plant extracts toward pomegranate aphid, *Aphis punicae* (*Passerini*) under laboratory conditions. African Journal of Agricultural Research, 6 (10), 2425–2429. https://doi.org/10.5897/AJAR11.294

Mokhtari R., Fard M.K., Rezaei M., Moftakharzadeh S.A., Mohseni A., 2023. Antioxidant, antimicrobial activities, and characterization of phenolic compounds of thyme (*Thymus vulgaris* L.), sage (*Salvia officinalis* L.), and thyme–sage mixture extracts. Journal of Food Quality, 2023, Article ID 2602454, 9 pages. https://doi.org/10.1155/2023/2602454

Molole G.J., Gure A., Abdissa N., 2022. Determination of total phenolic content and antioxidant activity of *Commiphora mollis* (Oliv.) Engl. resin. BMC Chemistry, 16 (1), 48. https://doi.org/10.1186/s13065-022-00841-x

Mourad B., Rachid B., Sihem B., 2018. Antioxidant activity and phenolic content of *Artemisia campestris* from two regions of Algeria. World Journal of Environmental Biosciences, 7 (2), 61–66.

Mwangi R.W., Mustafa M., Charles K., Wagara I.W., Kappel N., 2023. Selected emerging and reemerging plant pathogens affecting the food basket: a threat to food security. Journal of Agriculture and Food Research, 14, 100827. https://doi.org/10.1016/j.jafr.2023.100827

Naimi I., Tastift M.A., Zefzoufi M., Gadhi C., Ba M'hamed T., Bouamama H., 2025. Chemical characterization, anti-cholinesterase and insecticidal activities of Moroccan *Artemisia absinthium* L. leaf extracts against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Journal of Stored Products Research, 112 (1), 102635. https://doi.org/10.1016/j.jspr.2025.102635

Ngegba P.M., Cui G., Khalid M.Z., Zhong G., 2022. Use of botanical pesticides in agriculture as an alternative to synthetic pesticides. Agriculture, 12 (5), 600. https://doi.org/10.3390/agriculture12050600

Noureldeen A., Kumar U., Asad M., Darwish H., Alharthi S., Fawzy M.A., Al-Barty A.M., Alotaibi S.S., Fallatah A., Alghamdi A., Albogami B., Alkashgry N., 2022. Aphicidal activity of five plant extracts applied singly or in combination with entomopathogenic bacteria, *Xenorhabdus budapestensis*, against rose aphid, *Macrosiphum rosae* (Hemiptera: Aphididae). Journal of King Saud University – Science, 34, 102306. https://doi.org/10.1016/j.jksus.2022.102306

Onanuga A.O., Oloyede G.K., 2022. Phytochemical analysis and antifungal activity of *Costus lucanusianus* J. Braun & K. Schum aerial and rhizome crude extracts. GSC Biological and Pharmaceutical Sciences, 18 (2), 215-223. https://doi.org/10.30574/gscbps.2022.18.2.0068

Othman A., Mukhtar N.J., Ismail N.S., Chang S.K., 2014. Phenolics, flavonoids content and antioxidant activities of 4 Malaysian herbal plants. International Food Research Journal, 21 (2), 759–766.

Palaiogiannis D., Chatzimitakos T., Athanasiadis V., Bozinou E., Makris D.P., Lalas S.I., 2023. Successive solvent extraction of polyphenols and flavonoids from *Cistus creticus* L. leaves. Oxygen, 3 (3), 274–286. https://doi.org/10.3390/oxygen3030018

Pandey G., Rathore H., 2023. Toxicity of strobilurins fungicides: a comprehensive review. Journal of Chemical Health Risks, 13 (2), 207–218. https://doi.org/10.22034/jchr.2023.1960279.1563

Pintye A., Bacsó R., Kovács G.M., 2024. Trans-kingdom fungal pathogens infecting both plants and humans, and the problem of azole fungicide resistance. Frontiers in Microbiology, 15, 1354757. https://doi.org/10.3389/fmicb.2024.1354757

Quezel P., Santa S., 1962. Nouvelle flore de l'Algérie et des régions désertiques méridionales. Éditions du Centre National de la Recherche Scientifique, Paris, 1170 p.

Rahim G., Qureshi R., Hazrat A., Ahmad B., Khan A.A., Aziz T., Alharbi M., Alshammari A., 2023. Phytochemical, antimicrobial, radical scavenging and in-vitro biological activities of *Teucrium stocksianum* leaves. Journal of the Chilean Chemical Society, 68 (1), 5748–5754. https://doi.org/10.4067/S0717-97072023000105748

Ranjbar M., Naghavi M.R., Alizadeh H., 2020. Chemical composition of the essential oils of Artemisia species from

Iran: a comparative study using multivariate statistical analysis. Journal of Essential Oil Research, 32 (4), 361-371. https://doi.org/10.1080/10412905.2020.1750495

Rizwana H., Alwahibi M.S., Soliman D.A., 2016. Antimicrobial activity and chemical composition of flowers of *Matricaria aurea*, a native herb of Saudi Arabia. International Journal of Pharmacology, 12 (6), 576–586. https://doi.org/10.3923/ijp.2016.576.586

Salari E., Ahmadi K., Zamani R., 2010. Study on the effects of acetonic extract of *Otostegia persica* (Labiatae) on three aphid species and one stored product pest. Advances in Environmental Biology, 4 (3), 346–349. https://www.researchgate.net/publication/235799744

Salem M.Z.M., Behiry S.I., El-Hefny M., 2019. Inhibition of *Fusarium culmorum*, *Penicillium chrysogenum* and *Rhizoctonia solani* by n-hexane extracts of three plant species as a wood-treated oil fungicide. Journal of Applied Microbiology, 126 (6), 1683–1699. doi: 10.1111/jam.14256

Madjitoloum Betoloum S., Talla E., Ngassoum M.B., Tsatsop Tsauge R.K., Nyemb J.N., Mahmout Y., 2018. Optimization of microwave-assisted extraction of total phenol content and total flavonoids content from *Anacardium occidentale* L. (*Anacardeaceae*) using response surface methodology. International Journal of Biochemistry and Biotechnology, 7 (4), 800–809.

Şabanoğlu S., Gökbulut A., Altun M.L., 2019. Characterization of phenolic compounds, total phenolic content and antioxidant activity of three Achillea species. Journal of Research in Pharmacy, 23 (3), 567–576. https://doi.org/10.12991/jrp.2019.164

Silva-Beltrán N.P., Boon S.A., Ijaz M.K., McKinney J., Gerba C.P., 2023. Antifungal activity and mechanism of action of natural product derivatives as potential environmental disinfectants. Journal of Industrial Microbiology and Biotechnology, 50 (1), kuad036. https://doi.org/10.1093/jimb/kuad036

Souto A.L., Sylvestre M., Tölke E.D., Tavares J.F., Barbosa-Filho J.M., Cebrián-Torrejón G., 2021. Plant-derived pesticides as an alternative to pest management and sustainable agricultural production: prospects, applications and challenges. Molecules, 26 (16), 4835. https://doi.org/10.3390/molecules26164835

Šamec D., Karalija E., Šola I., Vujčić Bok V., Salopek-Sondi B., 2021. The role of polyphenols in abiotic stress response: the influence of molecular structure. Plants, 10 (1), 118. https://doi.org/10.3390/plants10010118

Tabet Zatla A., Hammoudi A., Brikci Nigassa N., 2023. Analysis of the chemical composition and evaluation of antioxidant and anti-inflammatory properties of hydrosol extract and its principal component (Carlina oxide) in aerial parts of *Atractylis gummifera* from Western Algeria. Chemical Proceedings, 14 (1), 66. https://doi.org/10.3390/ecsoc-27-16135

Thakshila W.A.K.G., Dammini Premachandra W.T.S., Borgemeister C., 2022. Potential toxic effects of aqueous leaf extracts of *Calotropis gigantea* and *Croton laccifera* against *Aphis craccivora*. International Journal of Tropical Insect Science, 42, 1165–1173. https://doi.org/10.1007/s42690-021-00632-2

Toplan G.G., Taşkın T., İşcan G., Göger F., Kürkçüoğlu M., Civaş A., Ecevit-Genç G., Mat A., Başer K.H.C., 2022. Comparative studies on essential oil and phenolic content with *in vitro* antioxidant, anticholinesterase, antimicrobial activities of *Achillea biebersteinii* Afan. and *A. millefolium* subsp. *millefolium* Afan. L. growing in Eastern Turkey. Molecules, 27 (6), 1956. https://doi.org/10.3390/molecules27061956

Trifan A., Zengin G., Sinan K.I., Sieniawska E., Sawicki R., Maciejewska-Turska M., Skalikca-Woźniak K., Luca S.V., 2022. Unveiling the phytochemical profile and biological potential of five Artemisia species. Antioxidants, 11 (5) 1017. https://doi.org/10.3390/antiox11051017

Yang M., Li M., Chen F., Chen S., 2024. Bioactive components and antimicrobial potential of extracts from Artemisia species and their repellent activities against Aphid (*Macrosiphoniella sanborni*). Ornamental Plant Research, 4:e025. doi:10.48130/opr-0024-0021

Zakaria L., 2024. An overview of *Aspergillus* species associated with plant diseases. *Pathogens*, 13 (9), 813. https://doi.org/10.3390/pathogens13090813

Cite this article: Allouani, M., Hendel, N., Moutassem, D., … Madani, S. (2025). *Otospermum glabrum* extracts: antioxidant properties and bioactivity against fungal pathogens and *Aphis fabae*. Plant Protection Bulletin, 65-3. DOI: 10.16955/bitkorb.1613134

Atıf için: Allouani, M., Hendel, N., Moutassem, D., … Madani, S. (2025). *Otospermum glabrum* özleri: fungal patojenlere ve *Aphis fabae*'ye karşı antioksidan özellikler ve biyoaktivite. Bitki Koruma Bülteni, 65-3. DOI: 10.16955/bitkorb.1613134