

## Potential Anthelmintic and Antioxidant Activities of *Jasminum fruticans* L. and Its Phytochemical Analysis

Esra Küpeli Akkol<sup>1</sup>, Esma Kozan<sup>2</sup>, Hilal Bardakci<sup>3</sup>, Timur Hakan Barak<sup>3</sup>, Sara Khalilpour<sup>1</sup>

<sup>1</sup>Department of Pharmacognosy, Faculty of Pharmacy, Gazi University, 06330, Ankara, Turkey.

<sup>2</sup>Department of Parasitology, Faculty of Veterinary Medicine, Afyon Kocatepe University, 03200, Afyonkarahisar, Turkey.

<sup>3</sup>Department of Pharmacognosy, Faculty of Pharmacy, Acibadem Mehmet Ali Aydınlar University, 34752, Istanbul, Turkey.

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### Abstract

**Background:** Ethnobotanical investigations conducted in Turkey demonstrated that *Jasminum fruticans* L. extract and fruit juice had been used against parasites in animals. In this study, the possible anthelmintic activity of various *J. fruticans* extracts contributing to its traditional use, was relatively assessed. In addition, the antioxidant potentials and phytochemical composition of the extracts were investigated since there is a relationship between helminthiasis, oxidative stress and phenolic metabolites.

**Methods:** In this study, aerial parts of *J. fruticans* were subsequently extracted using *n*-hexane, ethyl acetate (EtOAc) and methanol (MeOH). *In vivo* anthelmintic activity of the extracts was compared with albendazole used as a reference in adult earthworms. Various methods, including free radical scavenging and metal-related activity assays, were used to assess the antioxidant capacity of the above-mentioned extracts. Assessment of phenolic composition was accomplished through total phenolic, phenolic acid, and flavonoid content assays as well as liquid chromatography-mass spectrometry (LC-MS/MS) using multiple reaction monitoring (MRM) scan modes. Further chlorogenic acid (3-O-caffeoylquinic acid) contents of extracts were quantified using high-performance thin-layer chromatography (HPTLC).

**Results:** Between all tested extracts, MeOH extract at a quantity of 50.0 mg/mL, paralysed worms in 8.1 min and killed them in 12.8 min, showing a high anthelmintic effect similar to albendazole. Similarly, *in vitro* DPPH radical scavenging activity, cupric ion reduction and total antioxidant capacity experiments demonstrated that MeOH extract had significant antioxidant activity. Further phytochemical screening showed that MeOH extract was richer regarding phenolic metabolites. Chlorogenic acid, ferulic acid, caffeic acid and gallic acid were only detected in the MeOH extract.

**Conclusion:** Results justify and support the use of *J. fruticans* in traditional medicine as an anthelmintic agent. Furthermore, a positive correlation was found between the strong antioxidant capacity along with the phenolic composition determined in the MeOH extract and anthelmintic activity.

### Introduction

Helminthiasis is the most frequent infection caused by helminths, mainly in underdeveloped or developing countries. It occurs abundantly in diverse tropical and semitropical regions and is unfortunately categorised as a squalid tropical illness. *Trichuris trichura*, *Ancylostoma duodenale*, *Necator americanus*, *Ascaris lumbricoides* and *Schistosoma* spp. filarial nematodes have been reported to infect more than one billion people as a rival to AIDS and malaria.<sup>1</sup> World Health Organization (WHO) reported that roughly one billion people globally are known to be infected with Ascariasis, 400 million people with hookworm agents, and 300 million people with Schistosomiasis.<sup>2</sup> Helminths

can enter the organism through the consumption of untreated drinking water or undercooked meat of infected animals, as well as through the skin wounds, mosquitoes and insect bites, even while swimming or by walking on dirty soil.<sup>1,3</sup> While parasites that cause obstruction and hyperplasia in the bile duct, cause symptoms characterized by liver dysfunction in mild infections, they cause hepatitis and digestive disorders in severe infections.<sup>4</sup> The chance of success of anthelmintic treatment varies depending on the type of helminth, its location in the host and the number of parasites as well. While, in general, anthelmintic drugs are effective against helminths that are located in the gastrointestinal system, systemic infections involving

\*Corresponding Author: Esra Küpeli Akkol, E-mail: esrak@gazi.edu.tr

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tissues, such as Echinococcosis, Cysticercosis, Filariasis and Toxocariasis, can be partially treated with these. In such cases, surgical or other interventions may be required.<sup>5</sup> The drugs used in the treatment act either as helminthicide or helminthifuge.<sup>3</sup> Currently, synthetic anthelmintic drugs cause gastrointestinal problems and headache as side effects.<sup>6</sup> Therefore, discovery of natural compounds with less side effects is important.<sup>7</sup> The effectiveness and lower toxicity on humans, draw attention on folkloric medicinal plants. WHO reported that 80% of the world's population prefers traditional herbal products as first line treatment. Even in modern pharmacopoeias, at least 25% of products are made from plants and many semi-synthetic drugs are prepared from natural origins.<sup>8</sup>

There are many studies demonstrating the correlation between the oxidation mechanism of the cells and helminthiasis. Oxidative stress escalates with the amount of active oxygen species in host cells with parasitic infections. Infection of host cells via parasites is associated with higher release of free radicals, as involved in the pathogenesis of the most of the parasitic infections as well.<sup>9</sup> In addition, phenolic compounds with high antioxidant capacity have been used as anthelmintic in both traditional medicine and modern science. There are investigations claiming the curative effect of polyphenols in additional or alternative treatment of helminthiasis as well as new drug lead substances.<sup>10</sup>

The genus *Jasminum* (Oleaceae) commonly grows in tropical and temperate climates and has about 200 species distributed around the world.<sup>11</sup> In ethnobotanical studies on the many species belonging to *Jasminum* genus have been used in traditional medicine as antiparasitic<sup>12</sup> and wound healer,<sup>13</sup> in the treatment of dysmenorrhea, lepra,<sup>14,15</sup> acne,<sup>16</sup> rheumatoid arthritis and hepatitis.<sup>17</sup> It was also used externally against eye infections,<sup>18</sup> as an antispasmodic,<sup>19</sup> in stopping uterine bleeding;<sup>15, 20,21</sup> and as an oil obtained from flowers being used as a sedative in perfumery, soap industry and cosmetics industry, and aromatherapy.<sup>22-25</sup> In Turkey, the infusion prepared from the flowering branches of *Jasminum fruticans* L. is internally used as a urinary enhancer and sedative<sup>26</sup>, while water extract prepared from fresh branch ends is heated and used as anthelmintic.<sup>27</sup> Despite the traditional utilization as an anthelmintic agent for years, there is no previous study revealing anthelmintic activity available on *J. fruticans* yet.

Phytochemical studies revealed that *Jasminum* species are rich in phenylethanoid glycosides, flavonoids, lignans saponins, sesquiterpenes and especially secoiridoids.<sup>28-30</sup> In biological activity studies; *Jasminum* species have been found to have anti-inflammatory, analgesic,<sup>31-33</sup> antimicrobial,<sup>34</sup> antiviral,<sup>35</sup> antioxidant,<sup>36-38</sup> anthelmintic,<sup>39-43</sup> anticancer,<sup>44,45</sup> anti-obesity,<sup>46</sup> antiulcerogenic,<sup>47</sup> hepatoprotective,<sup>48</sup> wound healing<sup>49</sup> and urolithiatic<sup>50</sup> effects.

Although it is widely used in Turkish folk medicine, to our knowledge, *J. fruticans* efficacy in treating helminthiasis, antioxidant potential and major phenolic metabolites have not been studied in the literature. In this

study, we aimed to assess the *in vivo* anthelmintic activity, antioxidant potential and phytochemical composition of *J. fruticans* considering the ethnobotanical information.

## Material and Methods

### Plant Material

*Jasminum fruticans* flowering branches and leaves were collected near Ballıkuyumcu village in Ankara, Etimesgut district, in the second week of May in 2018. After drying in the shade, they were powdered and used in experimental studies. The herbarium sample was determined by Prof. Dr. Hayri DUMAN from Biology Department of Gazi University, Faculty of Science and the sample was stored in the Herbarium of Faculty of Pharmacy (Herbarium No: GUE 3462) of the same university.

### Plant Extracts

To conduct chemical and biological studies, the flowering branches of *J. fruticans* which were dried and powdered (500 g), were extracted by maceration technique with 5 L *n*-hexane, ethyl acetate (EtOAc) and methanol (MeOH) for two days, respectively, and then filtered. The extracts were separately pooled and reduced to dryness in a rotavapor at 40°C. The residues were mixed with water and lyophilized. The yields of *n*-hexane, EtOAc and MeOH extracts were calculated as 9.27%, 23.36% and 31.19%, respectively.

### Phytochemical Studies

#### Total phenolic content

The phenolic content of the extracts was interpreted using the spectrophotometric method of Spanos and Wrolstad.<sup>51</sup> 0.50 g gallic acid was dissolved in 100.0 mL of 10% ethanol as stock solution. A series of solutions, where dilutions increase gradually with 0.05 mg/mL increments, in a range between 0.05-0.50 mg/mL were prepared from this stock solution. 10 mg of each test sample was completed to 10 mL with distilled water in a flask. 100 µL of both diluted stock solutions and samples were transferred into tubes. 900 µL of distilled water; 5.0 mL of Folin Ciocalteu phenol solution (1:10) and 4.00 mL of Na<sub>2</sub>CO<sub>3</sub> solution (75.00 g/L) were added to each tube and left at room temperature in dark for 2h. A calibration graph was constructed after measuring the absorbance of the stock and diluted solutions at 765 nm. Then, total phenol amounts were calculated from the absorbance values of the samples using the graph.

#### Total flavonoid content

Total flavonoid content was measured using the spectrophotometric procedure of Woisky and Salatino.<sup>52</sup> After dissolving 500 µL test sample in distilled water, 1500 µL of 95% EtOH, 100 µL of 10% AlCl<sub>3</sub> and 100 µL of 1.00 M potassium acetate (KCH<sub>3</sub>COO) were added and mixed. Then the total volume was completed to 5000 µL with distilled water. After 30 min incubation at room temperature, absorbance was measured at 415 nm, using quercetin as reference. All measurements were performed triply and the total flavonoid content of the samples was

calculated by means of mg quercetin in each 1.00 g sample.

#### Total phenolic acid content

The total phenolic acid was measured utilizing the absorbance of the complex, formed by the reaction of hydroxycinnamic acid derivatives with the freshly prepared sodium molybdate-sodium nitrite mixture.<sup>53</sup> Arnow solution was prepared through adding 50.0 mL water to 5.0 g sodium molybdate and 5.0 g sodium nitrite. 1.00 mL test samples were transferred to the test tubes and the volume of each sample was completed to 10.0 mL after adding 1.00 mL of Arnow solution, 1.00 mL of 0.1 M HCl and 1.00 mL of 1.00 M NaOH solution in it. The absorbances of test samples were measured spectrophotometrically at 765 nm. The results were calculated as the caffeic acid equivalent corresponding to 1.00 g sample. All experiments were performed triply.

#### Phytochemical characterization of extracts using Liquid Chromatography-Electrospray Ionization- Triple Quad Mass Spectrometry (LC/ESI-MS/MS)

Phenolic content of extracts prepared from *J. fruticans* was determined using Agilent 1260 infinity series HPLC system (vacuum degasser, a binary pump and autosample) connected to an Agilent 6420 ESI-MS/MS by using previously published method of Bardakci *et al.*<sup>54</sup> Agilent Mass Hunter software was used for acquisition and data evaluation. Standards were prepared individually and as mixtures in methanol, in a 5.0–10.0 µg/mL concentration range. For optimization of the instrumental parameters, both individual solutions and a standard mixture were used. Standard solutions were injected directly into the

ion source for the optimization of ion source and MS/MS parameters. Mass range was set to 10–1200 m/z, negative ion mode to monitor single-charged ions of deprotonated phenolic compounds, [M-H]<sup>-</sup>. The optimized values of the ion source were: 250°C for N<sub>2</sub> drying gas temperature, 11 L/min for drying gas flow rate, 40 psi for nebulizer gas and 4000 V for capillary voltage.

Fragmentation of charged ions and precursor ions in MRM scanning were performed at a series of different voltages via changing capillary voltage and collision-induced dissociation voltage. In MRM scanning, the densest and most stable ion peaks of each compound were obtained for both of the precursor and product ion pairs, and then the fragmentation voltages and collision energies were re-optimized. The retention times, optimized fragmentation voltages, collision energies and MRM transition values of the analytes are given in Table 1.

Inertsil ODS column (Zorbax Eclipse Plus 4.6×100 mm i.d., 3.5 µm particle size) from Agilent was used along with a gradient flow using mobile phase A: MeOH:H<sub>2</sub>O:Formic acid (10:89:1, v/v/v) and mobile phase B: MeOH:H<sub>2</sub>O:Formic acid (89:10:1, v/v/v). Flow rate was 0.40 mL/min with constant column temperature of 25 °C. The mobile phase ratio of B was increased from 0% to 10% within the first 5 min. Then it was increased to 100% within 45 min and kept at this ratio for 5 min more. The optimized injection volume was set to 10 µL, as higher volumes caused peak distortions.

#### High-Performance-Thin-Layer Chromatography (HPTLC)

The chlorogenic acid amounts in the extracts were measured using the HPTLC procedure of Cretu *et al.*<sup>55</sup>

**Table 1.** Retention times, MRM transitions and optimized fragmentor voltages (FV) and collision energies (CE) of standard phenolic compounds.

No	Compound	Molecule Weight	Retention Time	MRM Transition Value	FV	CE
1	Gallic acid	170.12 g/mol	4.67 min	169 m/z → 119 m/z	110 V	10 V
2	Catechin	290.271 g/mol	11.76 min	289 m/z → 245 m/z	130 V	5 V
3	Chlorogenic acid	354.311 g/mol	13.36 min	353 m/z → 191 m/z	100 V	10 V
4	Caffeic acid	180.159 g/mol	14.86 min	179 m/z → 135 m/z	120 V	10 V
5	Epicatechin	290.271 g/mol	15.50 min	289 m/z → 245 m/z	150 V	10 V
6	p-coumaric acid	164.16 g/mol	18.76 min	163 m/z → 119 m/z	90 V	10 V
7	Ferulic acid	194.186 g/mol	19.83 min	193 m/z → 134 m/z	100 V	15 V
8	Isoorientin	448.380 g/mol	20.45 min	447 m/z → 327 m/z	170 V	15 V
9	Vitexin	432.381 g/mol	21.22 min	431 m/z → 311 m/z	130 V	15 V
10	Luteolin-7-O-glucoside	448.38 g/mol	22.90 min	447 m/z → 285 m/z	190 V	20 V
11	Verbascoside	624.592 g/mol	23.06 min	623 m/z → 161 m/z	210 V	25 V
12	Leucoseptoside A	638.619 g/mol	23.24 min	637 m/z → 461 m/z	240 V	20 V
13	Hyperoside	464.379 g/mol	23.55 min	463 m/z → 300 m/z	170 V	25 V
14	Rutin	610.521 g/mol	23.74 min	609 m/z → 151 m/z	210 V	25 V
15	Rosmarinic acid	360.318 g/mol	24.69 min	359 m/z → 161 m/z	100 V	10 V
16	Apigenin-7-O-glucoside	432.381 g/mol	25.05 min	431 m/z → 268 m/z	200 V	30 V
17	Quercitrin	448.38 g/mol	25.78 min	447 m/z → 301 m/z	160 V	15 V
18	Martinoside	652.646 g/mol	26.23 min	651 m/z → 175 m/z	230 V	25 V
19	Quercetin	302.238 g/mol	29.08 min	301 m/z → 151 m/z	150 V	15 V
20	Naringenin	272.256 g/mol	29.01 min	271 m/z → 151 m/z	140 V	15 V
21	Apigenin	270.240 g/mol	32.72 min	269 m/z → 117 m/z	150 V	30 V
22	Caffeic acid phenethyl ester (CAPE)	284.311 g/mol	36.95 min	283 m/z → 179 m/z	160 V	10 V

Standard chlorogenic acid solutions (31.25 µg/mL) and extracts were dissolved in methanol and filtered through a 0.45 µm syringe filter. Six different standard chlorogenic acid solutions with 5.0 µL of extract (2.0–8.0 µL) were analyzed triplicately. The sample and standard solutions were applied at a constant rate, as 8 mm bands with 10 mm gaps on silica gel coated 60 F<sub>254</sub> HPTLC glass plates with the Camag Automated TLC Sampler IV. The mobile phase was EtOAc:CH<sub>3</sub>COOH:CH<sub>2</sub>O<sub>2</sub>:H<sub>2</sub>O (100:11:11:27). Developments were carried out in Camag Automatic Developing Chamber (ADC-2). Humidity was controlled with ADC-2 using MgCl<sub>2</sub> (33% RH) for 10 min. Using Camag Derivatizer, 2.00 mL of natural product reagent (2-aminoethyl diphenylborinate) was sprayed and then heated at 100°C for 5 min using a Camag heater after 70 mm drift. Densitometric scanning was performed in fluorescence mode using Camag TLC Scanner IV and Vision CATS software after derivation. The slit size was kept at 5×0.2 mm, the micro and scan speed was set at 20 mm/s. The coefficient of variation (CV %) was observed to be below 1.00 with and the correlation coefficient (R) of the calibration curve was above 0.999. Presence of chlorogenic acid in the extracts was demonstrated via overlaying both R<sub>f</sub> values and UV spectra obtained from extracts and standard solutions.

#### **Anthelmintic activity**

Adult earthworms (length:3-5 cm, width:0.1-0.2 cm) were used to investigate the anthelmintic activity, as they resemble round intestinal worms found in humans anatomically and physiologically. After the worms were collected from the moist soil and they were freed of particles adhered to body surfaces washed with normal saline water. Albendazole was used as reference.<sup>56</sup>

Each experimental group had six worms. Test samples were dissolved in the minimum amount of dimethylformamide, and then the volume was completed to 10.0 mL with normal saline water. All test samples and reference albendazole solution were freshly prepared. Test samples and reference drug solution were poured into different petri dishes and all worms were washed in 10.0 mL normal saline water and placed in petri dishes. Experimental groups were classified as follows:  
 -Control group: 5% dimethylformamide solution,  
 -Reference substance group:  
 Albendazole solution (20.0 mg/mL),  
 -*n*-hexane, EtOAc and MeOH extract groups: *n*-hexane, EtOAc, MeOH extracts of flowering branches and leaves of *J. fruticans* (Concentration levels for each group: 10.0, 25.0 and 50.0 mg/mL).

Throughout the experiment, the time for the worms to be paralyzed (not reviving even in normal saline water) and to die (losing its mobility and then body color) was recorded. All results were expressed as the statistical mean±S.D. of six worms in each group.

#### **Antioxidant activity**

*Assessment of antioxidant potential depending on free radical-scavenging capacity*

##### **2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging effect test**

The DPPH experiment protocol Blois (1958) was applied.<sup>57</sup> 5000 µL (0.10 mM) freshly prepared DPPH solution was added onto 1000 µL of test samples which are prepared in various concentrations (1000-750-500-250-200-125-100 µg/ml) in methanol and vortexed for 2 min. The resulting solution was incubated at room temperature for 50 min at dark. Distilled water and butylated hydroxytoluene (BHT) were used as the blank and reference solutions consequently. The absorbance was measured at 517 nm.

##### **Assessment of antioxidant potential depending on metal chelating activity**

##### **Ferric reducing antioxidant power (FRAP)**

FRAP was performed according to the method by Bardakci *et al.*<sup>58</sup> 10 µL test sample (in 1000 µg/ml concentration) in solubilized in methanol, 30 µL distilled water and 260 µL FRAP reagent [300 mM pH 3.6 acetate buffer: 10 mM TPTZ: 20 mM FeCl<sub>3</sub> (10:1:1)] were placed in a 96-well plate and incubated at 37°C for 30 min. After the incubation period was completed, absorbance values were measured colorimetrically at 593 nm. As the control group, distilled water was used where BHT was reference material. The calibration curve was prepared using FeSO<sub>4</sub>.7H<sub>2</sub>O at different concentrations in the range of 0.0625 mM-1.00 mM. Results were calculated on FeSO<sub>4</sub>.7H<sub>2</sub>O corresponding to 1.00 g test sample.

##### **Cupric reducing antioxidant capacity (CUPRAC)**

Extracts of CUPRAC were measured using the method of Apak *et al.*<sup>59</sup> Using a 96-well plate, equal volumes (85 µL) of CuSO<sub>4</sub>, neocuproine and ammonium acetate solutions were mixed. 43 µL test sample (in 1000 µg/ml concentration) was added at room temperature and incubated for an hour. The calibration curve was constructed using ascorbic acid solution in the concentration range of 31.25-500.00 µg/mL. Absorbances were measured at 450 nm. Results were calculated as ascorbic acid equivalent (AAE) of 1.00 g test sample. All experiments were conducted in triplicate.

##### **Determination of total antioxidant capacity**

The total antioxidant capacity was measured using the method of Prieto *et al.*<sup>60</sup> 300 µL mixture prepared with 280.0 mg sodium phosphate monobasic, 247.2 mg ammonium molybdate, 164.6 µL sulfuric acid and 50.0 mL distilled water, was mixed in a tube with 30 µL test sample and left to incubate at 95°C for 90 min. After the incubation was completed, the results were measured using a spectrophotometer at 695 nm. A calibration curve was created using the ascorbic acid solution in a range of 31.25-500.00 µg/mL as a standard. Results were calculated as gallic acid equivalent (GAE) in 1.00 g test sample. All experiments were conducted in triplicate.

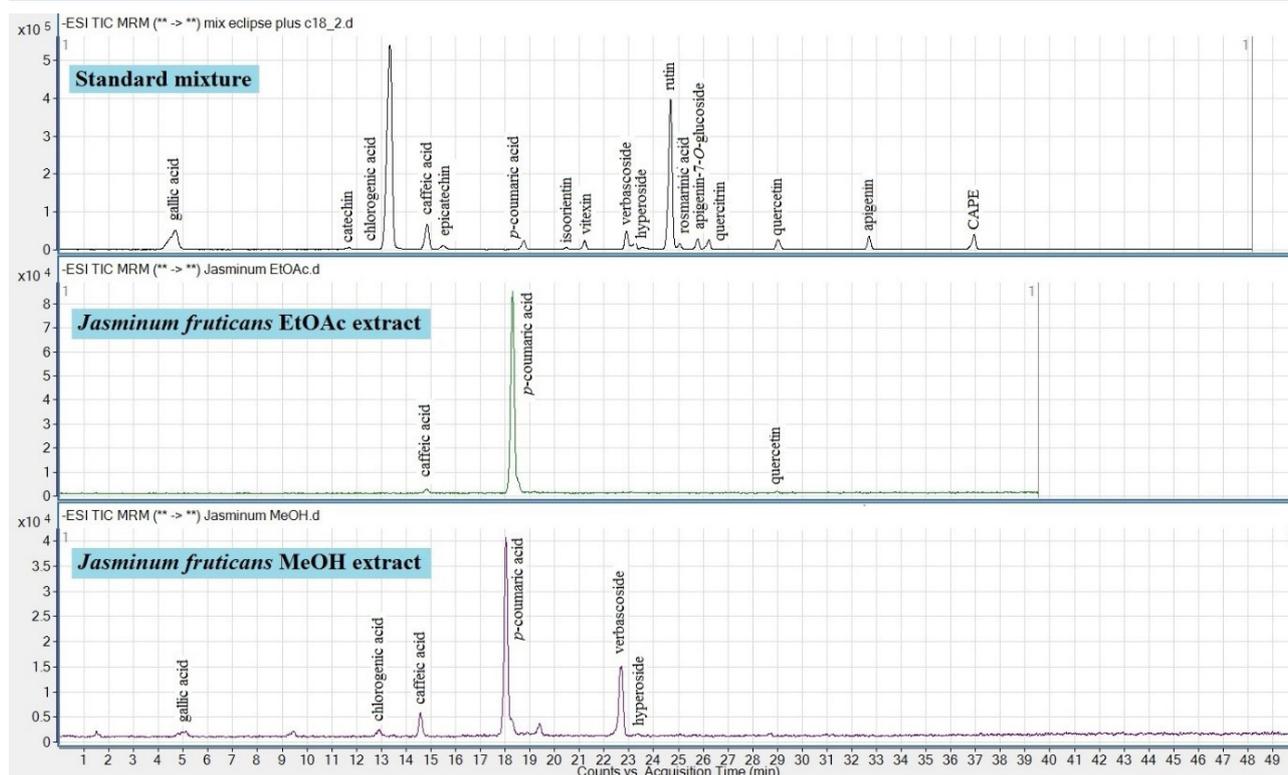


Figure 1. LC/ESI-MS/MS TIC chromatograms of the standard mixture, EtOAc and MeOH extracts of *J. fruticans*.

### Statistical evaluation

For evaluation of experiment results, the “Instat” (Windows) statistics program, including the one-way “ANOVA” test and the Students-Newman-Keuls posthoc test, were used. The statistical significance of the experimental results compared with the control and reference groups was expressed as \*:  $p < 0.05$ ; \*\*:  $p < 0.01$ ; \*\*\*:  $p < 0.001$

### Results

The success rate of anthelmintic therapy varies depending on the type of helminth, location in the host, and the number of parasites. An anthelmintic drug acts by damaging the cuticle, which causes the worm to paralyze, be partially digested or be rejected by immune mechanisms. However, most of the anthelmintic drugs may cause serious side effects and products with a lower side effect profile are needed. In this study, the anthelmintic and antioxidant activities of *J. fruticans*, which has a traditional use as anthelmintic in folk medicine, were investigated. In order to conduct chemical and biological studies, the flowering branches and leaves of the *J. fruticans* were gradually extracted with *n*-hexane, EtOAc and MeOH.

LC/ESI-MS/MS in MRM scan mode was used to determine the phenolic content. Compounds with close retention times were clearly separated from each other with the confidence of their MRM values (Figure 1; Table 2).

The results showed that *p*-coumaric acid was the major ingredient in both EtOAc and MeOH extracts. However, the presence of gallic acid, caffeic acid, ferulic acid and chlorogenic acid (3-*O*-caffeoylquinic acid) were detected

Table 2. Phenolic profiling of *J. fruticans* MeOH and EtOAc extracts by LC/ESI-MS/MS.

No	Compound	ETOAC	MeOH
1	Gallic acid	-	+
2	Catechin	-	-
3	Chlorogenic acid	-	+
4	Caffeic acid	+	+
5	Epicatechin	-	-
6	<i>p</i> -coumaric acid	+(major)	+(major)
7	Ferulic acid	+	+
8	Isoorientin	-	-
9	Vitexin	-	-
10	Luteolin-7- <i>O</i> -glucoside	-	-
11	Verbascoside	-	+
12	Leucoseptoside A	-	-
13	Hyperoside	+	+
14	Rutin	+	+
15	Rosmarinic acid	-	-
16	Apigenin-7- <i>O</i> -glucoside	-	-
17	Quercitrin	-	-
18	Martinoside	-	-
19	Quercetin	+	-
20	Naringenin	+(trace)	-
21	Apigenin	-	-
22	CAPE	-	-

in the MeOH extract. Unlike the MeOH extract, gallic acid and chlorogenic acid could not be detected in the EtOAc extract or remained below the LOD value. Further, spectrophotometric assays revealed that the total phenolic content of the MeOH extract was significantly higher than

**Table 3.** Results of the total phenolic profile of extracts prepared from *J. fruticans* (n=3).

Material	Total phenolic content	Total flavonoid content	Total phenolic acid content
<i>n</i> -Hexane Extract	nd	38.67 ± 0.49 <sup>c</sup>	20.32 ± 0.76 <sup>c</sup>
EtOAc Extract	24.75 ± 0.98 <sup>b</sup>	49.28 ± 0.85 <sup>b</sup>	30.91 ± 0.49 <sup>b</sup>
MeOH Extract	82.70 ± 1.84 <sup>a</sup>	70.78 ± 1.86 <sup>a</sup>	48.07 ± 1.55 <sup>a</sup>

nd: no detected; \*p-value: (p < 0.005). <sup>a,b,c</sup> statistically significant difference (p < 0.05). Results were expressed as the mean of triplicates ± standard deviation (S.D.), as mg gallic acid equivalents (GAE) in 1 g sample for the total amount of phenolic content; as mg quercetin equivalents (QE) in 1 g sample for the total flavonoid content; re as mg caffeic acid equivalents (CAE) in 1 g sample for total phenolic acid content.

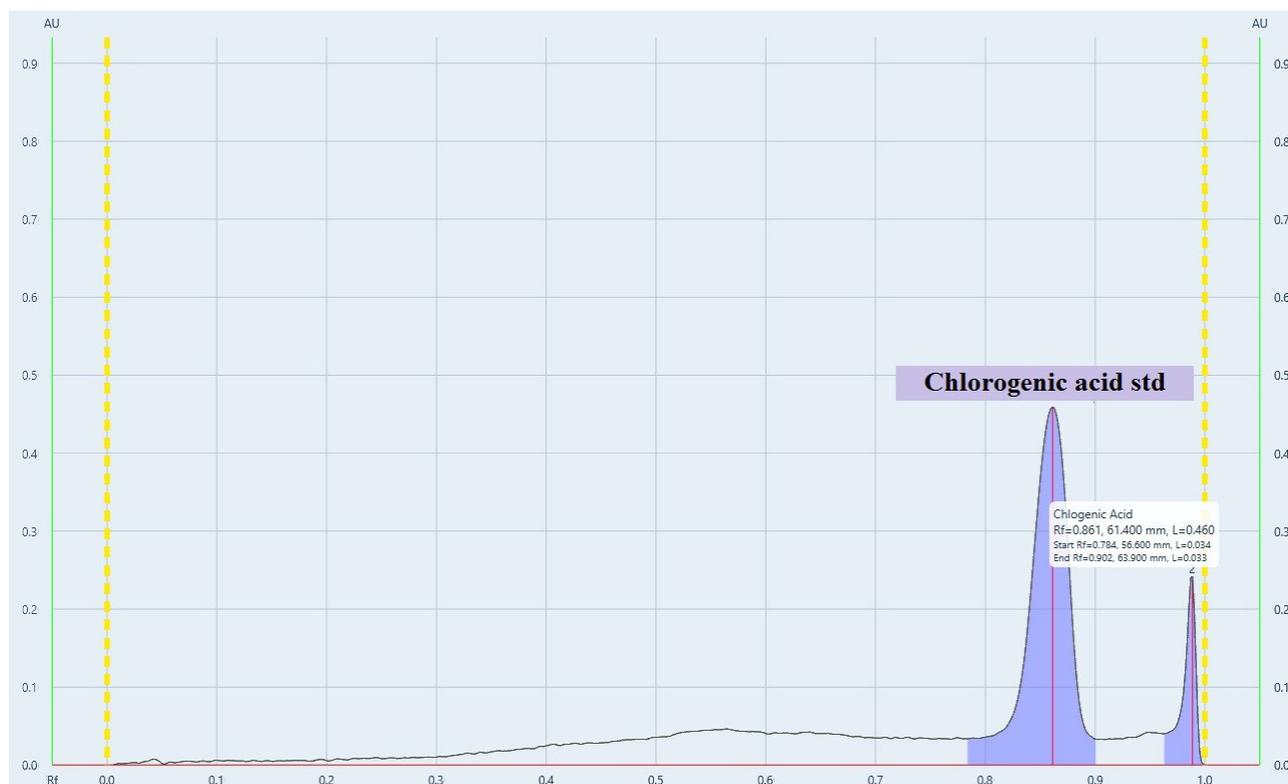
the EtOAc extract. The total phenol content of the *n*-hexane extract was less than the minimum required amount to be obtained, so the total phenolic substance couldn't be determined in it. The flavonoid and phenolic acid content of the MeOH extract was determined to be higher than the *n*-hexane and EtOAc extracts (Table 3).

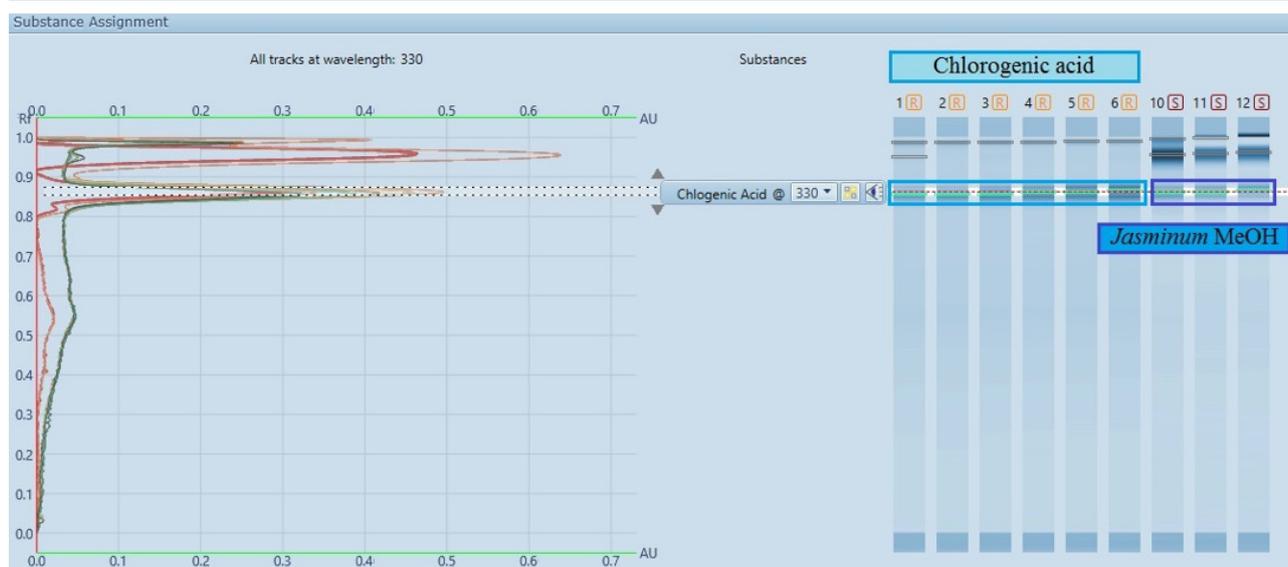
As a result of HPTLC analysis, chlorogenic acid was 1.34% in the MeOH extract but could not be calculated in other extracts, which were consistent with the MS/MS results. The presence of chlorogenic acid in the extraction has been demonstrated by comparison of their R<sub>f</sub> values as well as the one-to-one overlap of their UV spectra (Figures 2 and 3).

Antioxidant activity test results of *n*-hexane, EtOAc and MeOH extracts are presented in Table 4. The MeOH extract was found to have a strong antioxidant effect in DPPH radical scavenging activity, cupric ion reduction and total antioxidant capacity experiments, followed by EtOAc extract. Similarly, MeOH extract had a significant ferric ion reducing activity compared to EtOAc extract, whereas *n*-hexane extract had no measurable ferric ion

reducing activity.

The anthelmintic activity test results showed that the time required for paralysis and death of worms was less in the MeOH extract of *J. fruticans* compared to the EtOAc and *n*-hexane extract. MeOH extract caused paralysis in 8.1 min and death in 12.8 min in worms at a concentration of 50.0 mg/mL; paralysis in 15.4 min and death in 20.5 min at 25.0 mg/mL, and paralysis in 25.5 min and death in 30.7 min at 10 mg/mL. EtOAc extract caused paralysis in 11.3 min and death in 16.9 min in worms at 50.0 mg/mL; paralysis in 19.2 min and death in 23.2 min at 25.0 mg/mL, while paralysis in 22.4 min and death in 34.6 min at 10 mg/mL. *n*-Hexane extract caused paralysis in 14.7 min and death in 22.1 min in worms at a concentration of 50.0 mg/mL; paralysis in 30.1 min and death in 37.7 min at 25.0 mg/mL and paralysis in 51.3 min and death in 59.4 min at 10 mg/mL. Albendazole, which was used as a reference drug, caused paralysis in 6.3 min and death in 10.2 min in worms at 20.0 mg/mL (Table 5). The results showed that the MeOH extract prepared from the flowering branches of *J. fruticans* demonstrate very similar results to the

**Figure 2.** Densitometric chromatogram of standard chlorogenic acid and its R<sub>f</sub> value.



**Figure 3.** Densitometric chromatogram of standard chlorogenic acid and *Jasminum fruticans* MeOH extract.

**Table 4.** *In vitro* antioxidant activity of extracts prepared from flowering branches and leaves of *J. fruticans* (n=3).

Material	DPPH Scavenging Activity	Frap Activity	CUPRAC Activity	Total Antioxidant Capacity
<i>n</i> -Hexane Extract	6561.37 ± 51.89 <sup>c</sup>	nd	96.63 ± 3.49 <sup>c</sup>	69.25 ± 5.96 <sup>c</sup>
EtOAc Extract	2829.81 ± 26.22 <sup>b</sup>	0.38 ± 0.002 <sup>b</sup>	177.70 ± 4.81 <sup>b</sup>	209.00 ± 11.16 <sup>b</sup>
MeOH Extract	753.39 ± 15.89 <sup>a</sup>	0.93 ± 0.004 <sup>a</sup>	372.00 ± 8.15 <sup>a</sup>	278.01 ± 15.29 <sup>a</sup>

nd: no detected; <sup>a,b,c</sup> statistically significant difference (p<0.05). Results were expressed as the mean of triplicates ± standard deviation (S.D.), and as EC<sub>50</sub> in µg/mL equivalents for DPPH activity; as mM FeSO<sub>4</sub> equivalents in 1 g sample for FRAP activity; for CUPRAC a total antioxidant capacity activity, and as mg ascorbic acid equivalents (AAE) in 1 g sample. 1) EC<sub>50</sub> value of the reference compound "butylated hydroxytoluene (BHT)" in DPPH scavenging activity is found to be 368.19 ± 10.33. 2) FRAP activity of the reference compound "butylated hydroxytoluene (BHT)" is found to be 2.26 ± 0.18 mM FeSO<sub>4</sub> eq. in 1 g sample.

**Table 5.** Comparison of the anthelmintic effects of extracts prepared from *J. fruticans* flowering branches and leaves with Albendazole.

Test sample	Concentration (mg/mL)	Time to paralysis (min)	Time to death (min)
Control group	-	-	-
<i>n</i> -Hexane Extract	10	51.3±2.0	59.4±1.9
	25	30.1±2.2	37.7±2.1
	50	14.7±1.1	22.1±1.4
EtOAc Extract	10	22.4±0.9	34.6±1.0
	25	19.2±1.2	23.2±1.4
	50	11.3±1.3	16.9±1.6
MeOH Extract	10	25.5±1.3	30.7±1.5
	25	15.4±1.0	20.5±1.1
	50	8.1±1.1	12.8±1.2
Albendazole	20	6.3±1.0	10.2±1.0

reference drug albendazole. Anthelmintic drugs, such as albendazole, cause paralysis of worms and allow them to be eliminated via feces in humans and animals. In our study, it was determined that extracts caused both paralysis and the death of worms.

## Discussion

Helminthiasis is a disease characterized by the localization of helminths caused by parasitic and multicellular organisms in the lumen of the gastrointestinal tract, blood and lymph vessels and some other tissues. These infections are among the most common ones in large part of the world that may cause various ailments, such as anemia,

eosinophilia, pneumonia and malnutrition.<sup>61</sup> In some cases where the immune system is suppressed, the course of this disease can be very severe and fatal. In fact, it is a disease that needs to be treated because it sometimes induces a hypersensitivity reaction that leads to chronic allergic reactions characterized by anaphylaxis.<sup>1</sup>

In the literature reviews, it is reported that gallic acid, caffeic acid, ferulic acid and chlorogenic acid, which were determined to be in high amounts in the MeOH extract in the LC/ESI-MS/MS results, have strong antioxidant effects. The potent antioxidant and DNA damage protective effects were reported for caffeoylquinic acids, dicaffeoylquinic acids, caffeic acid and its derivatives.<sup>62,63</sup> The antioxidant

properties of ferulic acid are related to its protective role in cellular structures and inhibition of melanogenesis.<sup>64</sup> The antioxidant effect of gallic acid leads to antimicrobial and immunomodulatory effects.<sup>65</sup> In this study, the high antioxidant activity results observed in the MeOH extract was directly proportional to the amount of phenolic substances.

The aqueous extract prepared from the aerial parts of *J. polyanthum* remaining above the ground was found to have an EC<sub>50</sub> 6.41 on *Teladorsagia circumcincta* and the EC<sub>50</sub> of methanol extract was 14.58.<sup>43</sup> The aqueous extract prepared from the *J. polyanthum* demonstrated a high anthelmintic effect and low toxicity. Ethanolic extract of *J. sambac* leaves was reported to cause 11.3%, 13.3% and 26.7% mortality at concentrations of 100, 200, 500 ppm on *Aedes aegypti* larvae, 72 hours after application.<sup>66</sup> Lethal and paralyzing effects of the methanolic extract of the leaves of the *J. mesnyi* at concentrations of 20-40 mg/mL on the *Eisenia fetida* parasite, were equivalent to albendazole.<sup>41</sup> Chloroform, methanolic and aqueous extracts of *J. grandiflorum* leaves were found to have effects on the adult worm, *Pheretima posthuma* and higher anthelmintic activity compared to the reference drug albendazole, at concentrations of 20 and 40 mg/mL.<sup>42</sup> Ethanolic extracts of *J. arborescens* leaves were shown to speed up the paralysis and decrease the killing time of *Pheretima posthuma*.<sup>67</sup> The petroleum ether extract of the above-ground parts of the *J. multiflorum* was demonstrated to have an anthelmintic effect on *Pheretima posthuma*, equivalent to piperazine citrate and albendazole, at a dose of 25 mg/mL.<sup>40</sup> Kozan et al.<sup>39</sup>, showed that ethanolic and aqueous extracts prepared from the branches of the *J. fruticans* had strong anthelmintic effect on *Syphacia obvelata*.

In many preclinical and clinical studies, the total oxidant level, which is a general indicator of oxidant molecules, has been found to be high in subjects with parasitic infections. So, the effectiveness of antioxidants has been reported to be very important in strengthening the immune system and in the treatment of helminthic effects. Antioxidants contribute to the anthelmintic effect as they increase the activity of many anthelmintic drugs, such as praziquantel, and artesunate, causing severe morphological changes or parasite death during the developmental stages of the parasite.<sup>67-69</sup>

In this study, the correlation between antioxidant capacity and anthelmintic activity was supported by chromatographic and biological studies. We highly consider that our study can contribute to the studies conducted for the development of new anthelmintic drug/drug molecules and can be regarded a resource on the way from plant to drug.

## Conclusion

The present work exhibited that all *Jasminum fruticans* extracts showed anthelmintic activity, whereas only MeOH extract showed remarkable antioxidant activity. This might be due to the phenolic composition of the aforementioned

extract. This study confirms the anthelmintic potential of *J. fruticans*, which has supported the traditional use of the aerial parts. Although the results of *in vivo* investigations revealed that the MeOH extract of *J. fruticans* might be used instead of albendazole, more studies are required to confirm its clinical effects on humans.

## Author Contributions

EKA: Conceptualization, methodology, validation, formal analysis, investigation, data curation, writing-original draft preparation, writing-review and editing. EK: Anthelmintic activity analysis, investigation. HB: Methodology, chromatographic analysis, review and editing. THB: Antioxidant activity, editing. SK: Methodology. All authors read and gave approval of the final manuscript.

## Conflict of Interest

The authors report no conflicts of interest.

## References

1. James WD, Berger TG, Elston DM, Odom RB. Andrews' diseases of the skin: clinical dermatology. (10th ed). Philadelphia: Saunders Elsevier; 2006. p. 308-11.
2. Kozan E, Tatli II, Kahraman C, Kupeli Akkol E, Akdemir Z. The *in vivo* Anthelmintic Efficacy of some *Verbascum* Species growing in Turkey. *Exp Parasitol*. 2011;129:211-4. doi:10.1016/j.exppara.2011.06.005.
3. Dale MM, Ritter JM, Fowler RJ, Rang HP. Rang and Dale's Pharmacology (6th ed). Edinburgh: Churchill Livingstone; 2008. p. 712-13.
4. Watanapa P, Watanapa WB. Liver fluke-associated cholangiocarcinoma. *Br J Surg*. 2002;89(8):962-70. doi:10.1046/j.1365-2168.2002.02143.x
5. Guragac FT, Ilhan M, Kozan M, Kupeli Akkol E. Effective eradication of pinworms (*Syphacia obvelata* and *Aspiculuris tetraptera*) using *Polygonum cognatum* Meissn. *Exp Parasit*. 2019;196:63-7. doi:10.1016/j.exppara.2018.09.006
6. Kozan E, Ilhan M, Tumen I, Kupeli Akkol E. The Scolicidal Activity of the Essential Oil Obtained from the *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe on Hydatid Cyst. *J Ethnopharmacol*. 2019;235:243-7. doi: 10.1016/j.jep.2019.02.018
7. Khan PR, Karthikeyan M, Kannan M, Rajasekar S. Anthelmintic activity of *Nerium olender* flower extract in Indian adult earthworm. *J Nat Prod Plant Resour*. 2011;1(4):40-6.
8. Kalia AN. A textbook of industrial pharmacognosy. New Delhi: Satish Kumar Jain for CBS; 2005. p. 1-9.
9. Abd Ellah M. Involvement of free radicals in parasitic infestations. *J Appl Anim Res*. 2013;41(1):69-76. doi:10.1080/09712119.2012.739093
10. Spiegler V, Liebau E, Hansel A. Medicinal plant extracts and plant-derived polyphenols with anthelmintic activity against intestinal nematodes. *Nat Prod Rep*. 2016;34(6):627-43. doi:10.1039/c6np00126b
11. Yohanar R, Jeyarani NJ, Devipriya V, Rather SA,

- Kasana S, Thakur J, Pandey AK. Evaluating Genetic Diversity Within Genus *Jasminum* L. (Oleaceae) Using Intersimple Sequence Repeats (ISSR) Marker. Proc Natl Acad Sci India Sect B Biol Sci. 2020;90:531-40. doi:10.1007/s40011-019-01124-7
12. Ijaz F, Iqbal Z, Rahman IU, Alam J, Khan SM, Shah GM, Afzal A. Investigation of traditional medicinal floral knowledge of Sarban Hills, Abbottabad, KP, Pakistan. J Ethnopharmacol. 2016;179:208-33. doi:10.1016/j.jep.2015.12.050
13. Vidyalakshmi A, Selvi SE. Protease activity of floral extracts of *Jasminum grandiflorum* L., a wound healing herb. J Med Plants. 2013;1(4):11-5
14. Warriar PK, Nambiar VPK, Ramankutty C. Indian medicinal plants: A compendium of 500 species. Chennai: Orient Longman; 1996. p. 38-90.
15. Joshi SG (Ed.). Medicinal plants. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd; 2000. p. 298-300.
16. Saive M, Frederich M, Fauconnier ML. Plants used in traditional medicine and cosmetics in Mayotte Island (France): An ethnobotanical study. Indian J Trad Knowl. 2018;17(4):645-53.
17. Al-Snafi AE. Pharmacological and therapeutic effects of *Jasminum sambac*-A review. Indo Am J Pharmaceut Sci. 2018;5(3):1766-78. doi:10.22270/jddt.v9i2.2413
18. Meragiaw M, Asfaw Z, Argaw M. The status of ethnobotanical knowledge of medicinal plants and the impacts of resettlement in Delanta, northwestern Wello, northern Ethiopia. Evid Based Compl Altern Med. 2016;2016:5060247. doi:10.1155/2016/5060247
19. Lis-Balchin M, Hart S, Lo W.H.L.B. Jasmine absolute (*Jasminum grandiflora* L.) and its mode of action on guinea-pig ileum *in vitro*. Phytother Res: Int J Devoted Pharmacol Toxicol Evaluat Nat Prod Deriv. 2002;16(5):437-9. doi:10.1002/ptr.935
20. Kiritikar KR, Basu BD. Indian medicinal plants with Illustrations. 2nd Ed. Vol 7, 2003. p. 2093-6.
21. Khare CP. Encyclopedia of Indian Medicinal Plants, Rational Western Therapy. Ayurvedic and other Traditional usage. Botany: Springer Publications; 2004. p. 314-5.
22. Kang JY, Kim KS. Effect of aromatherapy on anxiety and fatigue in student's nurses experiencing their first clinical practice. J Korean Acad Fundam Nurs. 2002;9(2):226-36.
23. Hongratanaworakit T. Stimulating effect of aromatherapy massage with jasmine oil. Nat Prod Commun. 2010;5(1):157-62.
24. Younis A, Mehdi A, Riaz A. Supercritical carbon dioxide extraction and gas chromatography analysis of *Jasminum sambac* essential oil. Pak J Bot. 2012;43:163-8.
25. Mourya NMN, Bhopte DBD, Sagar RSR. A review on *Jasminum sambac*: A potential medicinal plant. Int J Indigenous Herbs Drugs. 2017;1:13-6.
26. Güler B, Manav E, Uğurlu E. Medicinal plants used by traditional healers in Bozüyük (Bilecik-Turkey). J Ethnopharmacol. 2015;173:39-47. doi:10.1016/j.jep.2015.07.007
27. Honda G, Yeşilada E, Tabata M, Sezik E, Fujita T, Takeda Y, Takaishi Y, Tanaka T. Traditional medicine in Turkey VI. Folk medicine in West Anatolia: Afyon, Kütahya, Denizli, Muğla, Aydın provinces. J Ethnopharmacol. 1996;53:75-87. doi:10.1016/S0378-8741(96)01426-2.
28. Shen YC, Chen CH. Multiflorin, A New Secoiridoid Lactone from *Jasminum multiflorum*. J Chinese Chem Soc. 1994;41(4):473-6. doi:10.1002/jccs.199400062
29. Shen YC, Lin SL, Hsieh PW, Chein CC. Secoiridoid glycosides from *Jasminum polyanthum*. J Chinese Chem Soc. 1996;43(2):171-6. doi:10.1002/jccs.199600025
30. Tanahashi T, Sakai T, Takenaka Y, Nagakura N, Chen CC. Structure elucidation of two secoiridoid glucosides from *Jasminum officinale* L. var. *grandiflorum* (L.) Kobuski. Chem Pharmaceut Bull. 1999;47:1582-6. doi:10.1248/cpb.47.1582
31. Rambabu B, Patnaik KR. Phytochemical screening and evaluation of analgesic, anti-inflammatory activity of alcoholic extract of *Jasminum sambac* on albino rats. World J Pharm Pharmaceut Sci. 2004;3(7):547-55.
32. Jia Q, Su W, Peng W, Li P, Wang Y. Anti-diarrheic and analgesic activities of the methanol extract and its fractions of *Jasminum amplexicaule* Buch.-Ham. (Oleaceae). J Ethnopharmacol. 2008;119(2):299-304. doi:10.1016/j.jep.2008.07.014
33. Sengar N, Joshi A, Prasad SK, Hemalatha S. Anti-inflammatory, analgesic and anti-pyretic activities of standardized root extract of *Jasminum sambac*. J Ethnopharmacol. 2015;160:140-8. doi:10.1016/j.jep.2014.11.039
34. Joy P, Raja DP. Antibacterial activity studies of *Jasminum grandiflorum* and *Jasminum sambac*. Ethnobotanical Leaflets 2008;1:59.
35. Chiang LC, Cheng HY, Liu MC, Chiang W, Lin CC. *In vitro* anti-herpes simplex viruses and anti-adenoviruses activity of twelve traditionally used medicinal plants in Taiwan. Biol Pharm Bull. 2003;26(11):1600-4. doi:10.1248/bpb.26.1600
36. Abdoul-Latif F, Edou P, Mohamed N, Ali A, Djama S, et al. Antimicrobial and antioxidant activities of essential oil and methanol extract of *Jasminum sambac* from Djibouti. Afr J Plant Sci. 2010;4(3):38-43.
37. Chaturvedi AP, Tripathi YB. Methanolic extract of leaves of *Jasminum grandiflorum* Linn modulates oxidative stress and inflammatory mediators. Inflammopharmacology. 2011;19(5):273-81. doi:10.1007/s10787-011-0087-3
38. Banerjee A, De B. Antioxidant activity of ethnomedicinally used flowers of West Bengal, India. J Pharmacognosy Phytochem. 2014;6(3):622-35.
39. Kozan E, Küpeli E, Yesilada E. Evaluation of some plants used in Turkish folk medicine against parasitic infections for their *in vivo* anthelmintic activity. J Ethnopharmacol. 2006;108(2):211-6. doi:10.1016/j.jep.2006.05.003

40. Pal D, Pahari SK, Mishra AK. Anthelmintic activities of roots of *Cocos nucifera* and aerial parts of *Jasminum multiflorum*. *Asian J Chem*. 2007;19(7):5089-92.
41. Dullu V. Anthelmintic activity of ethanolic leaf extract of *Jasminum mesnyi*. *Asian Pac J Trop Dis*. 2014;4:S273-S5. doi:10.1016/S2222-1808(14)60454-0
42. Radha R, Arathi CK, Santhoshkumar V, Thangakamatchi G. Pharmacognostical, phytochemical and anthelmintic activity on flowers of *Jasminum grandiflorum* Linn. (Oleaceae). *Int J Pharmacogn*. 2016;3(10):455-60.
43. Esteban-Ballesteros M, Sanchis J, Gutiérrez-Corbo C, Balaña-Fouce R, Rojo-Vázquez FA, González-Lanza C, Martínez-Valladares M. *In vitro* anthelmintic activity and safety of different plant species against the ovine gastrointestinal nematode *Teladorsagia circumcincta*. *Res Vet Sci*. 2019;123:153-8. doi:10.1016/j.rvsc.2019.01.004
44. Talib WH, Mahasneh AM. Antiproliferative activity of plant extracts used against cancer in traditional medicine. *Sci Pharm*. 2010;78(1):33-46. doi:10.3797/scipharm.0912-11
45. Takahashi M, Asikin Y, Takara K, Wada K. Screening of medicinal and edible plants in Okinawa, Japan, for enhanced proliferative and collagen synthesis activities in NB1RGB human skin fibroblast cells. *Biosci Biotech Biochem*. 2012;76(12):2317-20. doi:10.1271/bbb.120478
46. Yuniarto A, Kurnia I, Ramadhan M. Anti-obesity effect of ethanolic extract of jasmine flowers (*Jasminum sambac* (L) Ait) in high fat diet induced mice: potent inhibitor of pancreatic lipase enzyme. *Int J Adv Pharm Biol Chem*. 2015;4:18-22.
47. Nilesh M, Dinesh S, Dharendra S. Evaluation of anti-ulcer potential of leaves of *Jasminum grandiflorum* L. *Int J Pharm Dci*. 2009;1(2):247-9.
48. Joshi MC, Raju A, Arulanandham A, Saraswathy, G.R. Hepatoprotective activity of *Jasminum angustifolium* Linn. Against CCl<sub>4</sub> induced hepatic injury in rat. *Pharmacol Online*. 2008;3:197-205.
49. Mishra SB, Mukerjee A, Vijayakumar M. Wound healing activity of the aqueous alcoholic extract of *Jasminum grandiflorum* Linn leaves. *Pharmacol Online*. 2010;3:35-40.
50. Bahuguna Y, Rawat MSM, Juyal V, Gupta V. Antilithiatic effect of flowers of *Jasminum auriculatum* Vahl. *Int J Green Pharm*. 2009;3(2):154-58. doi:10.4103/0973-8258.54910.
51. Spanos GA, Wrolstad RE. Influence of processing and storage on the phenolic composition of Thompson seedless grape juice. *J Agric Food Chem*. 1990;38(7):1565-71. doi:10.1021/jf00097a030
52. Woisky RG, Salatino A. Analysis of propolis: some parameters and procedures for chemical quality control. *J Agric Res*. 1998;37(2):99-105. doi:10.1080/0218839.1998.11100961
53. Bardakci H, Celep E, Gozet T, Kan Y, Kirmizibekmez H. Phytochemical characterization and antioxidant activity of several *Crataegus* taxa. *South Afr J Bot*. 2019;124:5-13. doi:10.1016/j.sajb.2019.04.012
54. Bardakci H, Cevik D, Barak TH, Gozet T, Kan Y, Kirmizibekmez H. Secondary metabolites, phytochemical characterization and antioxidant activities of different extracts of *Sideritis congesta* P.H. Davis et Hub.-Mor. *Biochem Syst Ecol*. 2020;92:104120. doi:10.1016/j.bse.2020.104120
55. Cretu G, Morlock G, Raluca-Miron A, and Nechifor AC. A high-performance thin-layer chromatographic method for chlorogenic acid and hyperoside determination from berry extracts. *Rom Biotechnol Lett*. 2013;18(5):8657.
56. Nirmal SA, Malwadkar G, Laware RB. Anthelmintic activity of *Pongamia glabra*. *Songklanakarin J Sci Technol*. 2007;29(3):755-7.
57. Blois MS. Antioxidant determinations by the use of a stable free radical. *Nature* 1958;181(4617):1199-200. doi:10.1038/1811199a0
58. Bardakci H, Celep E, Gozet T, Kurt-Celep I, Deniz I, Sen-Utsukarci B, Akaydin G. A comparative investigation on phenolic composition, antioxidant and antimicrobial potentials of *Salvia heldreichiana* Boiss. ex Bentham extracts. *South Afr J Bot*. 2019;125:72-80. doi:10.1016/j.sajb.2019.07.010
59. Apak R, Güçlü K, Özyürek M, Karademir SE. Novel total antioxidant capacity index for dietary polyphenols and vitamins C and E, using their cupric ion reducing capability in the presence of neocuproine: CUPRAC method. *J Agric Food Chem*. 2004;52:7970-81. doi:10.1021/jf048741x
60. Prieto P, Pineda M, Aguilar M. Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: specific application to the determination of vitamin E. *Anal Biochem*. 1999;269(2):337-41. doi:10.1006/abio.1999.4019
61. Bundy D. The global burden of intestinal nematode disease. *Trans R Soc Trop Med Hyg*. 1994;88(3):259-61. doi:10.1016/0035-9203(94)90069-8
62. Xu JG, Hu QP, Liu Y. Antioxidant and DNA-protective activities of chlorogenic acid isomers. *J Agric Food Chem*. 2012;60(46):11625-30. doi:10.1021/jf303771s
63. Sidoryk K, Jaromin A, Filipczak N, Cmoch P, Cybulski M. Synthesis and antioxidant activity of caffeic acid derivatives. *Molecules*. 2018;23(9):2199. doi:10.3390/molecules23092199
64. Zduńska K, Dana A, Kolodziejczak A, Rotsztejn H. Antioxidant properties of ferulic acid and its possible application. *Skin Pharmacol Physiol*. 2018;31(6):332-6. doi:10.1159/000491755
65. Choubey S, Goyal S, Varughese LR, Kumar V, Sharma AK, Beniwal V. Probing gallic acid for its broad spectrum applications. *Mini Rev Med Chem*. 2018;18(15):1283-93. doi:10.2174/1389557518666180330114010
66. Dhanasekaran D. Influence of growth regulating chemicals on growth and flowering in Jasmine

- (*Jasminum sambac*. Ait.). J Hortl Sci. 2018;13(2):221-26. doi:10.24154/JHS.2018.v13i02.016
67. Bhagath K, Kekuda PTR, Raghavendra HL, Swarnalatha SP, Preethi HR, Surabhi KS. *In vitro* antioxidant and anthelmintic activity of extracts of *Jasminum arborescens* (Roxb.). Int J Drug Develop Res. 2010;2(1):89-95.
68. El-Shennawy AM, Mohamed AH, Abass M. Studies on parasitologic and haematologic activities of an enaminone derivative of 4-hydroxyquinolin-2 (1H)-one against murine schistosomiasis mansoni. MedGenMed. 2007;9(1):15.
69. Soliman MF, El Shenawy NS, El Arabi SE. Schistosoma mansoni: melatonin enhances efficacy of cercarial and soluble worm antigens in the induction of protective immunity against infection in the hamster. Exp Parasitol. 2008;119(2):291-5. doi:10.1016/j.exppara.2008.01.013-