Hindawi
Journal of Food Quality
Volume 2022, Article ID 1405157, 12 pages
https://doi.org/10.1155/2022/1405157

Research Article

GC-MS Analysis of Bioactive Compounds in Methanolic Extracts of *Papaver decaisnei* and Determination of Its Antioxidants and Anticancer Activities

Ahmed Aj. Jabbar,[1] **Fuad O. Abdullah**,[2,3] **Kamaran K. Abdulrahman**,[2] **Yaseen Galali**,[4,5] **and Abdullah Sh. Sardar**[6]

[1]*Department of Medical Laboratory Technology, Erbil Technical Health and Medical College, Erbil Polytechnic University, 44001 Erbil, Iraq*
[2]*Department of Chemistry, College of Science, Salahaddin University-Erbil, Erbil, Iraq*
[3]*Department of Pharmacognosy, Faculty of Pharmacy, Tishk International University, Erbil, Iraq*
[4]*Food Technology Department, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, Erbil, Iraq*
[5]*Department of Nutrition and Dietetics, Cihan University-Erbil, Erbil, Iraq*
[6]*Biology Department, College of Education, Salahaddin University, 44001 Erbil, Iraq*

Correspondence should be addressed to Ahmed Aj. Jabbar; ahmed.abuljabbar@epu.edu.iq

Received 24 February 2022; Revised 10 April 2022; Accepted 12 April 2022; Published 23 April 2022

Academic Editor: Christophe Hano

Copyright © 2022 Ahmed Aj. Jabbar et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The *Papaver* L. plant (*Papaver decaisnei*) has ethnobotanical records in many countries including Iraqi Kurdistan. The current study investigates the methanol (99.9%) extracts (10 μg/mL) of roots, leaves, and flowers of *Papaver decaisnei* in terms of phytochemistry by gas chromatography-mass spectrophotometry GC-MS, *in vitro* antioxidant activity by radical scavenging and reducing power assays, and finally, the anticancer actions as IC_{50} (inhibitory concentration at 50%) against human colorectal adenocarcinoma (Caco-2), mammary cancer cells (MCF-7), and human cervical carcinoma (HeLa) cells. The results showed 22, 19, and 17 chemicals for roots, leaves, and flowers of *P. decaisnei*, respectively. The prevalent organic compounds of *P. decaisnei* were alkaloids (62.03%), phenolics (55.43%), fatty acids (42.51%), esters (32.08%), terpenoids (25.59%), and phytosterols (15.68%), namely, roemerine (**70.44**%), 9,12,15-octadecatrien-1-ol (37.45%), hexadecanoic acid (33.72%), decarbomethoxytabersonine (24.49%), and γ-sitosterol (11.22%). The antioxidant activity of plant organs was within 39.1–143.5 μg/mL for DPPH, 135.4–276.4 μg/mL for ABTS, 12.4–34.3 μg/mL for FRAP, and 42.6–75.8 μg/mL for CUPRAC assays. The anticancer of *P. decaisnei* was found as 125.3–388.4 μg/mL against all tested cell lines (Caco-2, MCF-7, and HeLa). The detected alkaloids and bioactivity of *P. decaisnei* encourage future isolation of those remarkable alkaloids (reomerine) for potential usage in the pharmaceutical industry.

1. Introduction

The poppy *Papaver* L., Papaveraceae, has more than 820 species distributed into the 43 genera [1]. The Iraqi flora shows 15 *Papaver* geniuses with annual and perennial species, mostly growing in Iraqi Kurdistan (an autonomous region in Iraq) particularly about 80% of them were found in Rawanduz district. They include *P. acrochaetum Bornm.*, *P. argemone* L., *P. armeniaca L.*, *P. bornmuelleri Fedde.*, *P. curviscapum Nab.*, *P. cylindricum Cullen.*, *P. decaisnei Hochst.*, *P. dubium* L., *P. fuga xPoir.*, *P. glaucum Boiss.*, *P. hybridum L.*, *P. rhoeas L.*, *P. persicum Lindl.*, *P. macrostomum Boiss.*, and *P. somniferum* L. out of these species, and only *P. decaisnei* have not been screened phytochemically and biologically based on the systematic search in Google and SciFinder [2]. The *Papaver* species have different properties with more than 170 various alkaloids in their organs [3]. The alkaloids (thebaine, codeine, and

morphine) of *Papaver* species are industrially used for pharmaceutical products as a treatment for different health problems [4]. Thebaine is a known chemical for the production of pentacyclic morphinan-based drugs. Morphine, noscapine, and codeine were previously presented as analgesia as well as an antiproliferative drug for their significant remedial potency [5]. In more recent decades, the world's tendency to depend on the *Papaver* alkaloids and their derivatives as a remedy has remodified the drug production basics of major pharmaceutical companies [6]. Gas chromatography coupled with mass spectrometry is one of the fast and sensitive techniques for the identification of volatile compounds from plant extract. On this occasion in the present work, the GC-MS method was chosen to determination qualitative and quantitative for the complex product [7, 8].

Natural antioxidants and herbal medicine usage as antifree radicals become popular among health care due to the downsides of chemically synthetic drugs. The antioxidant potentials of *Papaver* species have been reported by numerous research studies [7–10]. This bioactivity of *Papaver* species has been correlated with their moderate hydrophilic secondary metabolites contents, namely, flavonoids, phenolic acids, and glycosides, as well as lipid-soluble compounds, namely, sterols, zeaxanthins, tocopherols, tocotrienols, and carotenoids, which were stated as antioxidants in several diseases involved with the oxidative stress [11, 12]. Alkaloids, namely, berberine, roemerine, amaranthine, thebaine, morphine, and noscapine, of *Papaver* species attracted scientists for further exploration due to their significant antitumor action and antioxidant activity [12–16].

The chemicals of *Papaver* species and their enriched alkaloid contents were always the central attention of plant breeders and investigation on different *Papaver* species and *Papaver* organs, and enlighten the plant breeders to grow the desired poppy genotypes with the most active functional compounds for the food and pharmaceutical industry and with less side effect for the sake of human health. Enlightened by that the present research explores the phytochemistry and bioactivity of MeOH extracts of roots, leaves, and flowers of *P. decaisnei* for the first time.

2. Materials and Methods

2.1. Plant Collection. The flowers, roots, and leaves of *P. decaisnei* were collected from Iraqi Kurdistan, Safeen Mountain (Altitude: 36.609153, Latitude: 44.526220). The identification of the plant was done by botanist Dr. Abdullah Sh. Sarder, and the voucher number (6548) was deposited from the Herbarium of the Salahaddin University Education College (HSUEC) as shown in Figure 1.

2.2. Plant Extract Preparation. The plant organs (roots, flowers, and leaves) were dried and an amount of 25 g each separately of P. decaisnei were taken for the extraction process by using 0.5 L of methanol (99.9%) and microwave (Samsung microwave 20 A3010, 10 power levels, frequency 50 MHz, Australia). The separation of solvents by rotary evaporator was performed in a water bath at 40°C for the crude preparation, further drying of the crude to exclude the solvent completely. The final crude extract for flowers, leaves, and roots was 9.72, 12.4, and 12.92% (w/w), respectively. The plant extracts were kept at +4°C for later analysis [17].

2.3. Phytochemical Profiling. The *Papaver* crude extracts were qualitatively investigated by using the GC/GC-MS technique to determine their phytochemical and alkaloid constituents. The methanol extract examined by Shimadzu Model QP-2010 GC coupled with MS. GC equipped with a capillary column (30 m × 0.25 mm i.d., film thickness 0.25 μm) and HP-5 MS (5% phenylmethyl siloxane) at a helium flow rate of 1.61 mL/minute with the temperature 60°C (2′) to 250°C for 10 minutes at a rate of 20°C/min. The ion source was maintained at 250°C and 70 eV electron energy. The methanol was added to the extracts before injecting 1 μl into the column. The exact name and molecular weight of unknown compounds were found by comparing their mass spectrum with the reference spectrum available in the Wiley GC/MS Library, Mass Finder Library, and Adams Library [16–19].

2.4. Antioxidant Activity. The antioxidant activity of *Papaver* organs was measured based on two different methods: firstly, by using free radical scavenging activity in 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays, and secondly, by measuring reducing power activity in Cupric reducing antioxidant capacity (CUPRAC) and ferric reducing antioxidant power (FRAP) assays. The antiradical action was expressed as a microgram of Trolox equivalents (TE) per milliliter as explained previously [20].

2.5. Anticancer Activity. The extracts of *Papaver* organs (flowers, leaves, and roots) were examined for anticancer efficacy based on their minimal inhibitory concentration (IC_{50}) to reduce the growth of MCF-7 (human breast adenocarcinoma), HeLa (human cervical cancer), and Caco-2 (human colorectal adenocarcinoma) cell lines by the MTT (3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyltetrazolium bromide) assay [21–25]. The live-cell count was done at 580 nm by using an ELISA plate reader as an equal number to the intensity of light absorbance as described previously [21–25].

2.6. Statistical Analysis. Statistical analysis of multivariate GC-MS experimental analysis by GC Shimadzu software was applied. The IC_{50} numbers were found as drug concentrations causing a 50% decrease in the viability or slowing the bioactivity. The IC_{50} numbers were calculated by a logistic curve of the four-parametric form (Sigma Plot 11.0) [26, 27]. The biological activity data were calculated by Student's t-test ($\alpha = 0.05$) and one-way analysis (ANOVA) from the SPSS v. 14.0 program version 24.0 for Windows. The values considered significant if $p < 0.05$ [28].



Figure 1: The plant parts ((a) flower, (b) poppy capsule, (c) stem, (d) root, and (e) leave) of *P. decaisnei* collected by A.A. Jabbar.

3. Results and Discussion

3.1. GC-MS Profile. The phytochemical qualitative study of extracts of *Papaver* organs (flowers, leaves, and roots) resulted in finding various alkaloids and chemicals as shown in Table 1, belonging to different organic classes as shown in Table 2. The chemical profiling of *P. decaisnei* plant organs, namely, roots, leaves, and flowers, showed 22, 19, and 17 chemicals, respectively, constituting 100% of their volatile contents as shown in Figures 2–4.

The chemical profiling of MeOH root extracts found Roemerine (70.44%) as the main compound in this organ, while some compounds were detected in a minor amount, including 3′-methyl-1′-phenylspiro (indoline-2,4'-(2) pyrazoline)-5′-one (5.16%), and hexadecanoic acid (2.66%) as shown in Table 1 and Figure 2. The biological and medicinal efficiency (alleviation symptoms of neurodegenerative diseases) of roemerine as a natural alkaloid has been reported by previous research studies [29]. A previous study by Hijazi et al. (2017) had reported roemerine as the main component of *P. libanoticum* with significant anticancer activity of its extract and alkaloid contents against human breast cancer and human colon cancer cells [30].

Similar to our high amount detection of roemerine in *P. decaisnei*, the previous study has reported an increased amount of alkaloid roemerine in *P. lacerum*, *P. syriacum, P. glaucum, and P. rhoeas* and considered it as a potential antidepressant drug [31]. The current phytochemical analysis of *P. decaisnei* also unrevealed alkaloids and chemicals in their organ extract as shown in Table 1 that were not discussed in the current article.

The prevalent chemical compounds of MeOH leave extracts were 9,12,15-octadecatrien-1-ol (25.45%), hexadecanoic acid (14.66%), 8. β,13 : 8. α,14(8.81%), γ-sitosterol (5.31%), neophytadiene (4.79), 2-methoxy-4-vinylphenol (4.14%), phytol (3.10%), and 6,8-dioxa-3-thiabicyclo (3,2,1) octane 3,3-dioxide (8.07%) as shown in Table 1 and Figure 3. Most of these chemicals have been linked with antioxidant and anticancer activity; for example, 9,12,15-octadecatrien-1-ol and hexadecanoic acids were previously shown as great antiradical and antitumor agents [32]. The same biological activity for γ-sitosterol has been shown by a recent study [33]. The chemical profiling of MeOH leave extracts of *P. decaisnei* also revealed some phytochemicals in minor amounts including octadecanoic acid (2.98%), 2,3-dihydrobenzofuran (2.68%), gibberellin a3 (2.55%), 2,4-di-tert-butylphenol (2.80%), and a few others, which were not explained in this report.

The GC-MS investigation of flower extracts showed 17 compounds (shown in Table 1 and Figure 4), which mainly includes decarbomethoxytabersonine (24.49%), hexadecanoic acid (16.40%), 9,12,15-octadecatrien-1-ol, (Z,Z,Z) (12%), glycerin (6.41%), γ-sitosterol (4.31%), benzyl benzoate (3.60%), amitriptylinoxide (3.59%), 3,4-dihydro-6,7-dimethoxyisoquinoline 2-oxide (5.62%), and 2H-Pyran-2-one, tetrahydro-4-hydroxy-4-methyl- (4.85%). Most of which have been found to act as antioxidant and anticancer agents; for example, decarbomethoxytabersonine has stated as a strong alkaloids showing significant antitumor and antiradical activity [34].

The major organic chemicals detected in 3 *Papaver* organs were belonging 5 classes, including alkaloids, phenolics, esters, terpenoids, and fatty acids, while the minor organic chemicals of three plant parts were related to coumaranes, fatty alcohols, organosulfur, and phytosterols as shown in Table 2. The present report about the chemical profile of *P. decaisnei* is found to be similar to a more recent chemical analysis of *P. decaisnei* by thin-layer chromatography (TLC), which concluded alkaloids as the most abundant organic class in *P. decaisnei*, namely, proaporphine-type mecambrine (PD2) and aporphine-type roemerine [35]. Furthermore, phytochemical profiling of *P. glaucum* has reported similar alkaloid compounds, namely, roemerine, roemerine N-oxide, rhoeagenine, and dehydroemetine [35]. Similar alkaloid constituents were detected from chemical profiling of *P. bracteatum* [36], *P. rhoeas* [37], and *P. somniferum* [14]. The chemical structures of the major detected phytochemicals in *P. decaisnei* are presented in Figure 5.

The systematic Google search and SciFinder did not find any previous research on the GC-MS profile of *P. decaisnei*. Therefore, the present work considered the first article on the phytochemistry of *P. decaisnei* organs (flowers, leaves, and roots).

Table 1: Phytochemical profile of roots, leaves, and flowers of *P. decaisnei* using GC-MS.

NO.	RT	Components name	Similarity	Peak area percentage %		
				PF	PL	Pr
1	7.55	Glycerin	9	6.41	–	–
2	8.666	Uracil, 1-N-Methyl-	59	–	1.76	–
3	8.686	Thymine	72	–	–	0.96
4	9.003	Guaiacol	94	1.85	–	0.99
5	10.259	4H-Pyran-4-one, 2,3-dihydro-3,5-Dihydroxy-6-Methyl-	72	–	–	1.19
6	10.58	Silane, triethylmethoxy-	72	1.99	–	–
7	11.021	2-Methyl[1,3,4]Oxadiazole	59	–	–	0.72
8	11.659	1,2-Benzenediol	81	–	–	0.54
9	12.038	2,3-Dihydro-Benzofuran	90	–	2.68	0.77
10	13.029	2H-Pyran-2-one, tetrahydro-4-hydroxy-4-methyl-	91	4.85	–	–
11	13.642	Trans-anethole	98	–	–	2.55
12	14.269	2-Methoxy-4-vinylphenol	96	2.18	4.14	1.63
13	15.079	2,6-Dimethoxyphenol	95	–	–	0.61
14	15.592	DL-Proline, 5-oxo-, methyl ester	78	2.80	–	0.44
15	16.127	Vanillin	96	–	–	0.52
16	17.201	6,8-Tioxa-3-thiabicyclo(3,2,1)octane 3,3-dioxide	47	–	8.07	2.49
17	17.958	1,6-Anhydro-beta.-D-Glucopyranose (levoglucosan)	47	2.67	–	–
18	18.457	2,4-Di-Tert-Butylphenol	96	–	2.80	–
19	18.462	Phenol, 2,4-bis(1,1-dimethylethyl)-	96	0.60		0.84
20	20.376	Alpha-cedrol	99	–	–	1.40
21	21.907	3a-Hydroxy-1,2,3,3a,8,8a-Hexahydropyrrolo (2,3b)Indole	90	–	–	0.45
22	22.763	4-Methoxy-6-methyl-2-Propylpyridine	50	–	–	1.27
23	23.297	Benzyl benzoate	98	3.59	2.52	–
24	24.496	Neophytadiene	96	–	4.79	–
25	25.944	Hexadecanoic acid, methyl ester	99	–	1.70	–
26	26.52	Hexadecanoic acid	99	16.40	14.66	2.66
27	28.725	Methyl 9,12,15-octadecatrienoate	99	–	2.19	–
28	28.901	Phytol	91	–	3.10	–
29	29.187	9,12-Octadecadienoic acid (Z,Z)-	96	3.47	–	1.45
30	29.192	Linoleic acid	97	–	2.18	–
31	29.29	9,12,15-Octadecatrien-1-Ol, (Z,Z,Z)-	94	12.00	25.45	–
32	29.607	Octadecanoic acid	98	–	2.98	–
33	35.32	8β,13 : 8.α,14-diepoxy-14,15-bisnorlabdane	86	–	8.81	–
34	35.325	Decarbomethoxytabersonine	56	24.49	–	–
35	35.382	Roemerine	58	–	–	**70.44**
36	36.145	3-(3Methoxyphenyl)Propenenitrile, 2-(Diethoxyphosphinyl)-	95	–	–	1.23
37	36.98	Butriptyline	72	–	2.25	–
38	36.98	Amitriptylinoxide	59	3.60	–	–
39	39.279	4-Methoxybenzene, 1-(2-hydroxynaphthylmethylenamino)-	95	–	2.08	–
40	39.284	3′-methyl-1′-Phenylspiro(Indoline-2,4′-(2)Pyrazoline)-5′-one	72	3.18	–	–
41	39.289	3′-methyl-1′-Phenylspiro(Indoline-2,4′-(2)Pyrazoline)-5′-one	72	–	–	5.16
42	43.139	3,4-Dihydro-6,7-Dimethoxyisoquinoline 2-oxide	43	5.62	–	–
43	43.238	Gibberellin A3	58	–	2.55	–
44	44.695	γ-sitosterol	95	4.31	5.31	1.69

Retention time (RT [min]) on a Restek RTX-5 column. Peak area percentage calculated from the GC-FID chromatogram. PF: *Papaver* flower, PL: *Papaver* leaves, PR: *Papaver* roots.

3.2. Antioxidant Activity. The investigation of antioxidant activity of *P. decaisnei* organs revealed the significant potentiality of this species as a strong antioxidant agent. This bioactivity of *P. decaisnei* could be linked with its phytochemicals, mainly alkaloid and polyphenolic compounds. The antioxidant activity was evaluated by two different methods, radical scavenging activity by DPPH and ABTS assays, and reducing power activity by FRAP and CUPRAC assays, as presented in Table 3. The antioxidant activity presented as $IC_{50,}$ represents the plant's ability to 50% of free radicals in essay reagents. The lesser the IC50 number of a plant extract is the higher the antioxidant efficacy is. Antioxidant activity evaluation by DPPH and ABTS assays showed higher values (39.1 and 135.4 μg/mL trolox) for flowers than that (81.35, 245.6 μg/mL trolox and 143.5, 276.4 μg/mL trolox) for leaves and roots, respectively. The antioxidant measurement by FRAP and CUPRAC assays revealed the highest values (12.4 and 42.6 μg/mL trolox) for leaves than that (18.3, 68.1 μg/mL trolox and 34.3, 75.8 μg/mL trolox) for roots and flowers, respectively.

The antiradical actions of different organs of *P. decaisnei* can be correlated with their different chemical constituents, namely, alkaloids, polyphenols, and phytosterols. The antioxidant activity of this compound has been also clarified by several research studies [33–37].

Table 2: Compound type of roots, leaves, and flowers of *P. decaisnei*.

No.	Compound type (total number in 3 plant organs)	% and (number) in PF	% and (number)in PL	% and (number) in PR
1	Alkaloids (12)	15.78 (3)	23.52 (4)	22.72 (5)
2	Phenolics (11)	10.52 (2)	17.64 (3)	27.27 (6)
3	Fatty acids (8)	15.78 (3)	17.64 (3)	9.09 (2)
4	Esters (6)	15.78 (3)	11.76 (2)	4.54 (1)
5	Terpenoids (5)	21.05 (4)	0 (0)	4.54 (1)
6	Phytosterol (3)	5.26 (1)	5.88 (1)	4.54 (1)
7	Coumaranes (2)	5.26 (1)	0 (0)	4.54 (1)
8	Organosulfur (2)	5.26 (1)	0 (0)	4.54 (1)
9	Alcohols (2)	5.26 (1)	5.88 (1)	0 (0)
10	Oxapanes (1)	0 (0)	5.88 (1)	0 (0)
11	Aromatics (1)	0 (0)	0 (0)	4.54 (1)
12	Others (5)	0 (0)	11.76 (2)	13.63 (3)
	Total	100%	100%	100%

The present research found flower extracts as the highest bioactive part in the antioxidant tests by DPPH and ABTS assays, which may be due to its phytochemical constituents, mainly terpenoids, fatty acids, and ester, namely, hexadecanoic acid, decarbomethoxytabersonine, and anthocyanins. The given data results are following the previous findings regarding the antioxidant activity of the mentioned phytochemicals [34, 38–46].

The reducing power estimation by FRAP and CUPRAC assays revealed the part of leaves as the most active part in the antioxidant activity. This bioactivity of leaves can be linked with its high alkaloid, fatty acids, and polyphenolic constituent, mainly 9,12,15-octadecatrien-1-ol, 8.β,13 : 8.α,14-diepoxy-14,15-bisnorlabdane and hexadecanoic acid. A similar study showed significant antioxidant activity of *Papaver rhoeas* L. leave extracts and linked this action with its increased phenolic contents [47, 48]. Furthermore, the another study by Trichopoulou et al. revealed significant antioxidant action of *Papaver* leaves and linked this action with their efficient flavonoid contents, namely, quercetin, isorhamnetin, kaempferol, and myricetin [49].

The present investigation of *P. decaisnei* root extract revealed a significant amount of roemerine, a known aporphine alkaloid, which is regarded as an efficient antioxidant and anticancer agent [50]. Furthermore, the antioxidant and anticancer potentials of aporphine compounds like roemerine have also been confirmed by D. Muthna and his colleagues [51]. Similarly, the antioxidant and antitumor capacity of alkaloids from plant sources have been confirmed [9, 37, 46–48]. The above-presented record could be enough evidence regarding the antioxidant activity of *P. decaisnei*.

3.3. Anticancer Activity. The anticancer action of *P. decaisnei* extracts was expressed as IC_{50}, a value that ranged between 125.3 and 388.4 μg/mL based on the plant's ability to inhibit the growth of MCF-7 (human breast adenocarcinoma), HeLa (human cervical cancer), and Caco-2 (human colorectal adenocarcinoma) as shown in Table 4. Moreover, doxorubicin as a standard reference was used on the mentioned cancer cell lines.

In recent years, herbal medicine and plant-derived compounds become a strong alternative source of synthetic drugs for the treatment of several tumor diseases such as hepatocellular carcinoma, human colorectal adenocarcinoma, and breast cancer. The main reason is because of fewer side effects of these natural compounds than chemical drugs. For that, multiple flowering herbs including *Papaver* species were used for medicinal and pharmaceutical purposes due to its increased alkaloids and aromatic hydrocarbon contents [52–55].

The *Papaver* alkaloids, namely, narcotine, morphine, codeine, narceine, and thebaine, from *P. somniferum*, and *P. libanoticum* are considered nitrogenous waste-producing chemicals with several pharmaceutical and biological activities including antidepressant, analgesia, and anticancer activity [15, 30, 39]. The antitumor action of herbal alkaloids brings more hope to the scientists in handling severe diseases due to the lower side effects of natural-based cures than chemically synthetic therapy. Thus, in the past few years, scientists have raced against the time to find an alkaloid with the highest indole ring activity and hydrocarbon chains against different cancer cell lines, because those properties have significant roles in drug delivery process [54, 56–58]. Enlightened by that the current study explores the cytotoxicity of methanolic extracts of *P. decaisnei* organs (flowers, leaves, and roots) against the viability of HeLa, Caco-2, and MCF-7 cancer cells. The present data revealed significant anticancer activity of extracts of MeOH leaves (176.2, 268.2 μg/mL) against Caco-2 and MCF-7 cell lines, which were higher than that (194.7, 388.4 μg/mL and 223.4, 306.5 μg/mL) for roots and flower extracts, respectively. This increased anticancer action of leave extracts can be correlated with its higher alkaloids, fatty acids, and phytosterols contents, namely, 9,12,15-octadecatrien-1-ol (25.45%), 8.β,13 : 8. α,14(8.81%), and γ-sitosterol (5.31%), and hexadecanoic acid (14.66%). The anticancer activity of the mentioned chemical compounds has been confirmed by multiple research studies [37, 53–60].

The anticancer action of MeOH root extracts of *P. decaisnei* against HeLa cell lines was higher (125.3 μg/mL) than that (165.3 μg/mL and 228.4 μg/mL) for leaves and flowers, respectively. This anticancer superiority of root

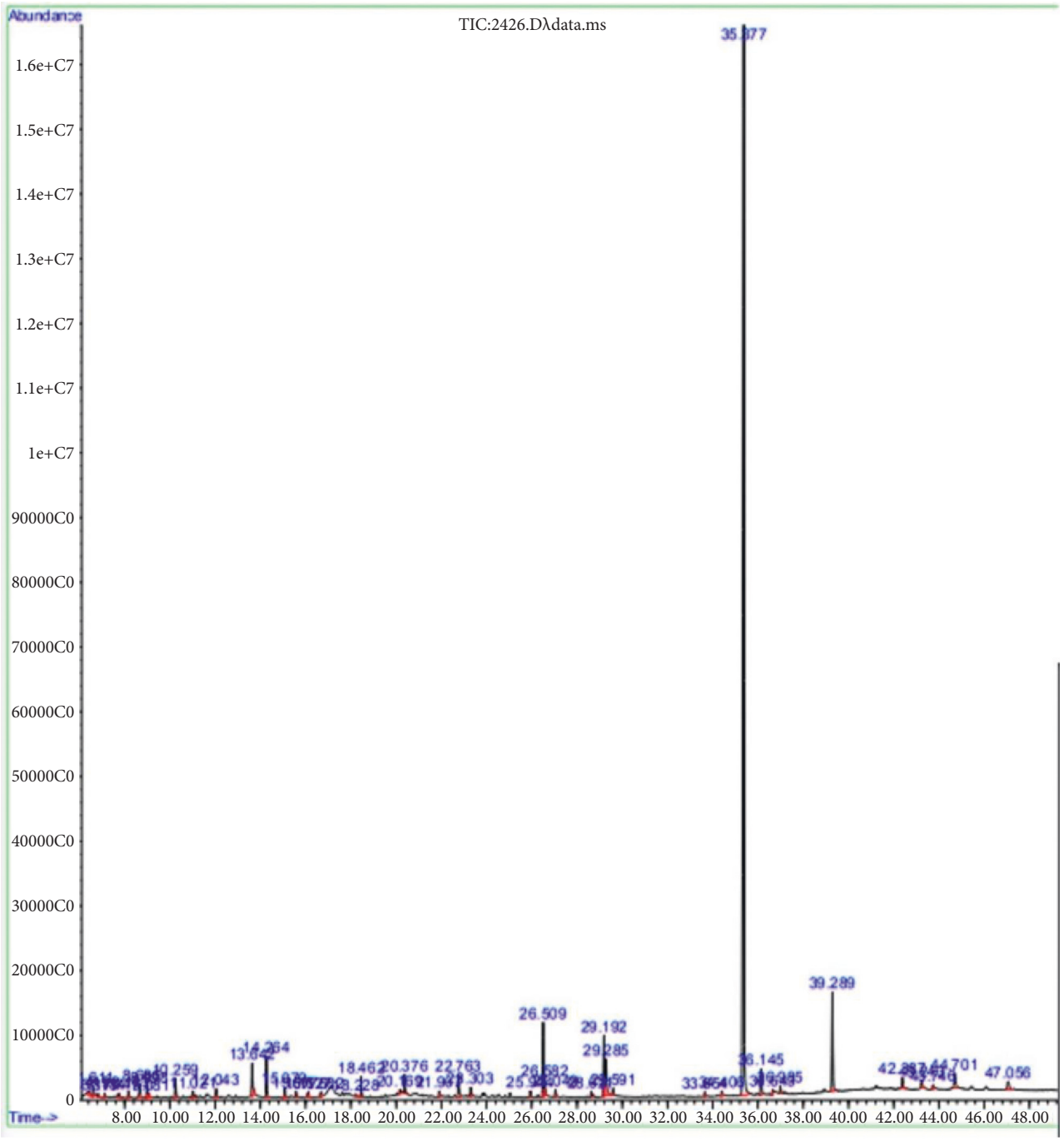


Figure 2: Chromatogram of MeOH root extracts of *P. decaisnei*.

extract against HeLa cell lines can be linked with its higher alkaloid and phenolic constituents, namely, roemerine (70.44%) and 3′-methyl-1′-phenylspiro(indoline-2,4′-(2) pyrazoline)-5′-one (5.16%).

Our data regarding highlighting the two mentioned compounds as anticancer agents are following the previous herbal bioactive studies [30, 61–63]. Furthermore, the cytotoxic mechanism of roemerine as the main alkaloid component of *P. libanoticum* and *Nelumbo nucifera* against several cancer cells has been linked to its ability to stimulate apoptosis, increase membrane permeability, and facilitate in cleavage of caspase-3, caspase-7, and caspase-9 in human cancer cells as clarified previously [30, 50, 64]. Similarly, to our results, researchers have also shown the superiority of MeOH root extracts of *P. somniferum* in reducing the growth of HeLa cell lines [15, 58, 65]. Moreover, based on several previous studies, the Papaveraceae members can be emphasized as a strong candidate for anticancer pharmaceutical production because of their high alkaloid contents [3, 9, 16, 40, 44, 50, 52]. The systematic Google search and

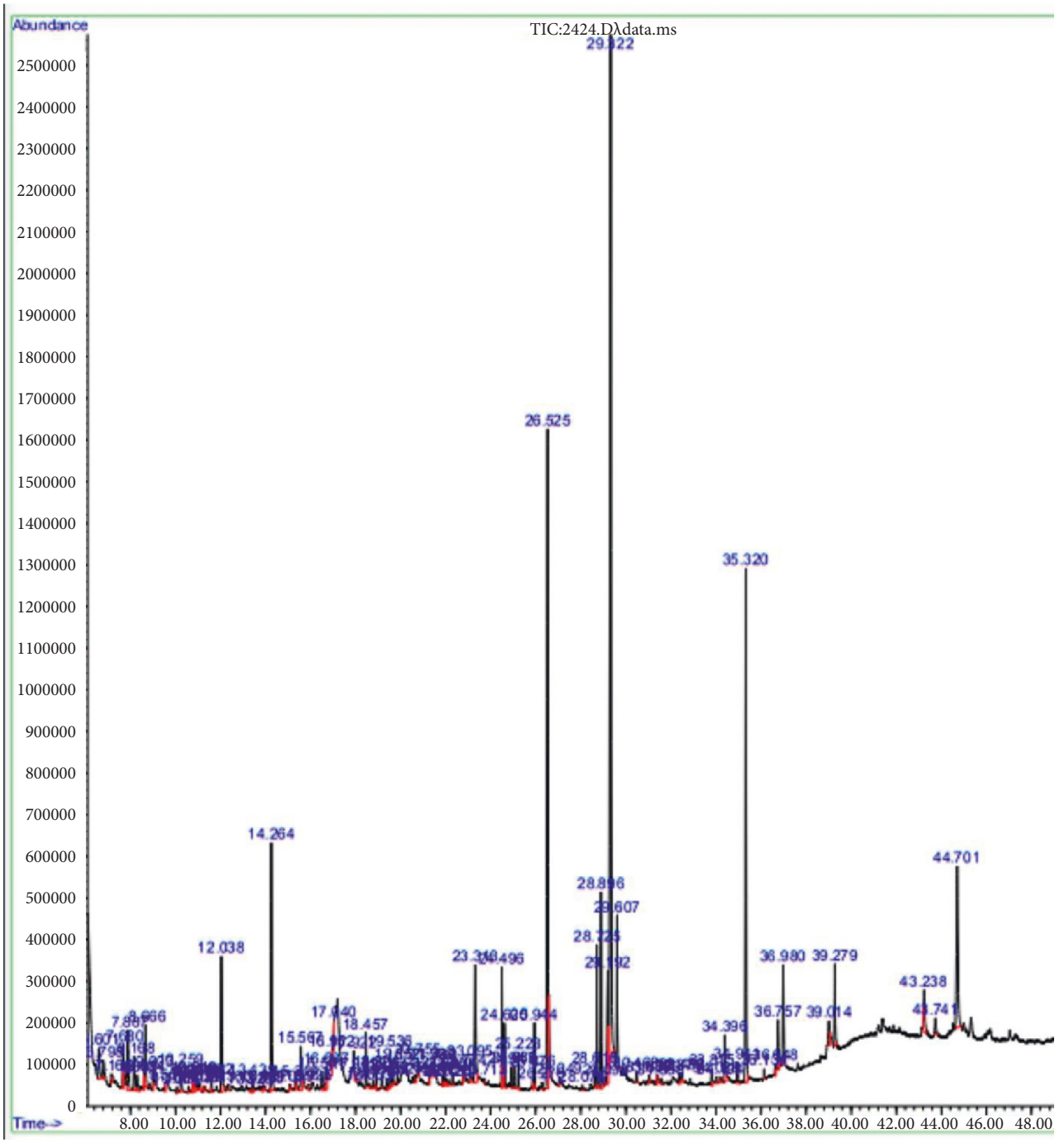


Figure 3: Chromatogram of MeOH leave extracts of *P. decaisnei*.

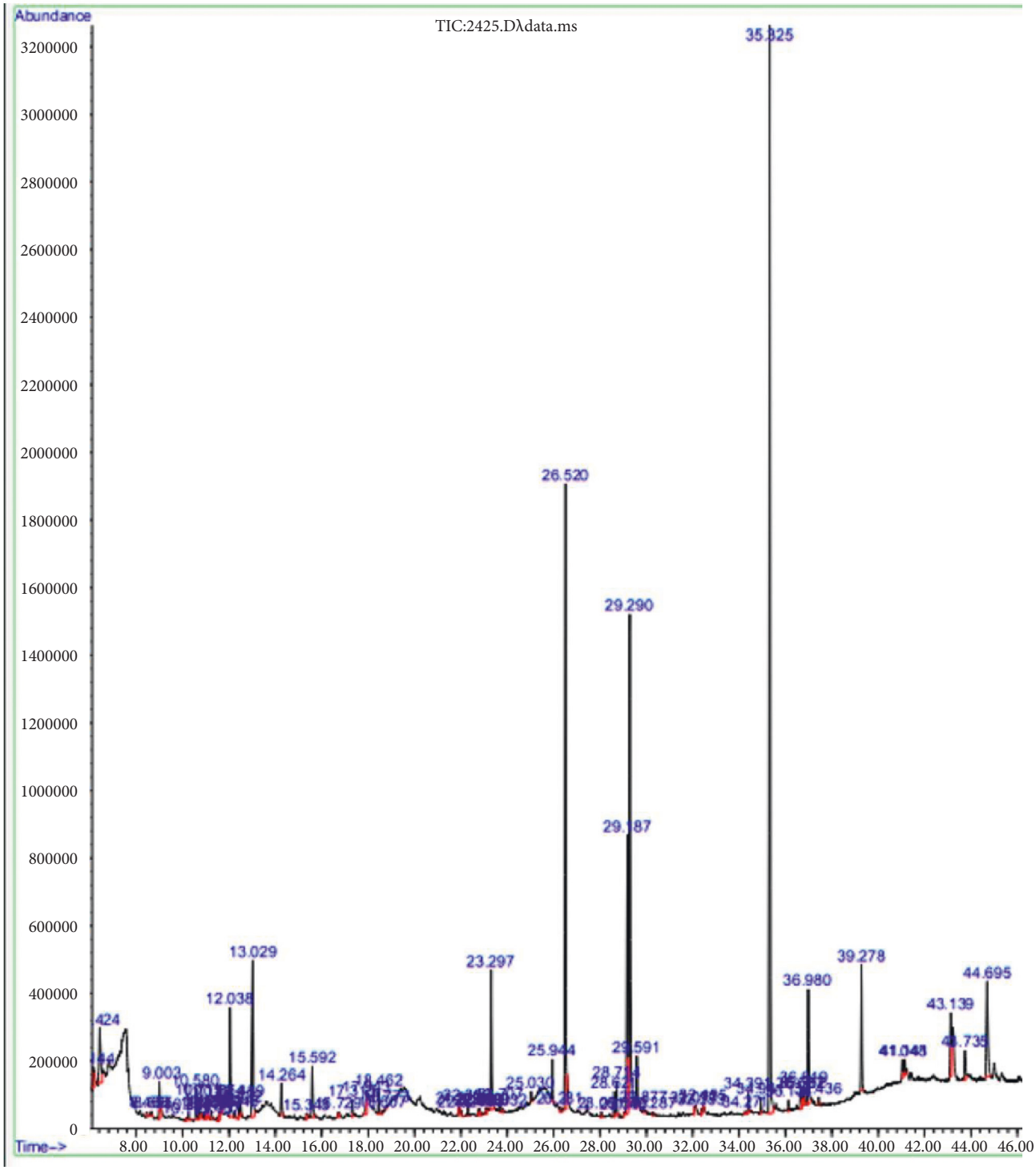


Figure 4: Chromatogram of MeOH flower extracts of *P. decaisnei*.

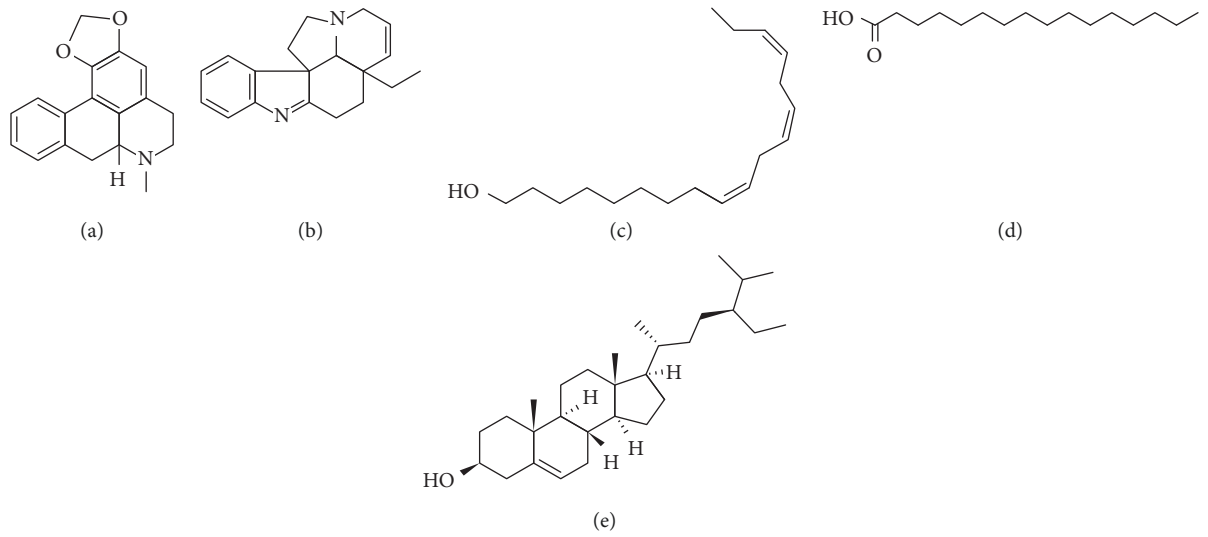


Figure 5: Chemical structures of the main representative components of methanolic extracts from roots, leaves, and flowers of *Papaver decaisnei*. (a) Roemerine, (b) decarbomethoxytabersonine, (c) 9,12,15-Octadecadien-1-ol, (d) hexadecanoic acid, (e) γ-sitosterol.

Table 3: Antioxidant activity of MeOH extracts of roots, leaves, and flowers of *P. decaisnei*[1].

Plant extracts	DPPH scavenging[2]	ABTS scavenging[2]	FRAP reducing[3]	CUPRAC reducing[3]
Flowers	39.1 ± 0.53^b	135.4 ± 0.78^b	34.3 ± 0.05^b	75.8 ± 0.9^b
Leaves	81.35 ± 0.111^a	245.61 ± 0.23^a	12.4 ± 0.08^a	42.6 ± 0.3^a
Roots	143.5 ± 3.06^a	276.4 ± 0.045^a	18.3 ± 1.023^c	68.1 ± 0.9^c
Trolox	1.4 ± 0.02^c	2.29 ± 0.02^c	2435.1 ± 0.01^d	2255.2 ± 0.02^d
EDTA[4]	ND[5]	ND	ND	ND

[1]The values indicated by different superscripts within the same column are different according to Tukey's honestly significant difference test at 5% significance level (value as mean ± standard deviation). [2]IC50 (μg/mL), inhibition concentration at which 50% of the DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2′-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) radicals were scavenged and the ferrous ion-ferrozine complex was inhibited. [3]EC50 (μg/mL) is effective concentration at which the absorbance was 0.5 for CUPRAC (cupric ion reducing antioxidant capacity) and FRAP (ferric reducing antioxidant power) assays. [4]EDTA: ethylenediaminetetraacetic acid (disodium salt). [5]ND: not detected.

Table 4: The anti-proliferative activity IC_{50} (μg/mL) of extract on human cell lines after 24 hr of treatment.

Cell line	IC_{50} values (μg/mL)[1]			
	Flowers MeOH extract	*Leaves MeOH extract*	*Roots MeOH extract*	DOX[2]
Caco-2	223.4 ± 2.1^c	176.2 ± 3.8^b	194.7 ± 6.5^b	6.7 ± 0.4^a
MCF-7	306.5 ± 9.8^b	268.2 ± 12.3^b	388.4 ± 11.2^c	18.8 ± 0.3^a
HeLa	228.4 ± 3.1^c	165.3 ± 2.3^b	125.3 ± 4.2^b	14.0 ± 0.1^a

[1]Mean value ± standard deviation ($n = 3$) of IC_{50} (μg/mL), inhibition concentration at which 50%. The values indicated by different superscripts within the same rows are different according to Tukey's honestly significant difference test at 5% significance level. [2]DOX: doxorubicin. Key: Caco-2 (human colorectal adenocarcinoma), MCF-7 (human breast adenocarcinoma), and HeLa (human cervical cancer) cells.

SciFinder did not find any previous anticancer record for *P. decaisnei*; therefore, the present work is considered as the first project studying the anticancer of *P. decaisnei*.

4. Conclusion

The present article showed GC-MS analysis, antiradical, and antitumor of roots, flowers, and leaves of *P. decaisnei* as the first report. The prevalent detected alkaloids of flowers were decarbomethoxytabersonine, hexadecanoic acid, and anthocyanin. Moreover, the analysis of MeOH leaves extract showed 9,12,15-octadecatrien-1-ol, hexadecanoic acid, and γ-sitosterol as their prevalent alkaloids. The prevalent alkaloid content of methanolic root extract was roemerine (70.44%), an alkaloid commonly used due to its antidepressant and antianxiety action. The antioxidant assays revealed the *Papaver* flower as the most active organ in DPPH and ABTS assays, while root extracts had the highest activity in reducing power activity by FRAP and CAPRAC assays. The antiproliferative analysis of roots, flowers, and leaves of *P. decaisnei* revealed significant potentials of *Papaver* organs against the proliferation of HeLa, Caco-2, and MCF-7 cell lines. The current research presents a ground knowledge on the phytochemical profile and bioactivity of *P. decaisnei* that could be used for future biomedical analysis and cancer study programs; however, a more detailed study

is required to investigate the toxicity and drawbacks of *P. decaisnei* as a potential remedy for different human diseases.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Ahmed Aj. Jabbar and Fuad O. Abdullah have structured, designed, and done the methodology. Kamaran K. Abdulrahman analyzed the results, and A. A Jabbar wrote the article with the guidance of all authors. All authors participated equally in reviewing and the finalizing manuscript.

References

[1] N. G. Walsh and J. Kellermann, *Flora of South Australia*, State Herbarium of South Australia, South Australia, 5th edition, 2013, https://data.environment.sa.gov.au/Content/Publications/FSA_Papaveraceae_02.pdf

[2] U. M. N. Almousawi and A. A. Alwan, "Distribution of the genus papaver L. in Iraq introduction distribution of the genus papaver L. in Iraq," *Basrah Journal of Science*, vol. 34, no. 1, pp. 9–24, 2016.

[3] A. Langlois, D. A. Mulholland, N. R. Crouch, and O. M. Grace, "Aporphine alkaloid from Papaver aculeatum (sect. Horrida; Papaveraceae) of southern Africa," *Biochemical Systematics and Ecology*, vol. 32, no. 11, pp. 1087–1090, 2004.

[4] H. Pathan and J. Williams, "Basic opioid pharmacology: an update," *British Journal of Pain*, vol. 6, no. 1, pp. 11–16, 2012.

[5] V. Tomar, S. Kukreti, S. Prakash, J. Madan, and R. Chandra, "Noscapine and its analogs as chemotherapeutic agent: current updates," *Current Topics in Medicinal Chemistry*, vol. 17, no. 2, pp. 174–188, 2016.

[6] B. Tisserat and M. Berhow, "Production of pharmaceuticals from papaver cultivars in vitro," *Engineering in Life Sciences*, vol. 9, no. 3, pp. 190–196, 2009.

[7] M. N. Wieczorek, K. Przygoński, and H. H. Jeleń, "Determination of 4-methylimidazole in ammonia caramel using gas chromatography–tandem mass spectrometry (GC-MS/MS)," *Journal of Food Quality*, vol. 2018, Article ID 4696074, 5 pages, 2018.

[8] Y. Qiao, J. Bi, Q. Chen et al., "Volatile profile characterization of winter jujube from different regions via HS-SPME-GC/MS and GC-IMS," *Journal of Food Quality*, vol. 2021, Article ID 9958414, 15 pages, 2021.

[9] G. Hussain, A. Rasul, H. Anwar et al., "Role of plant derived alkaloids and their mechanism in neurodegenerative disorders," *International Journal of Biological Sciences*, vol. 14, no. 3, pp. 341–357, 2018.

[10] M. Karajibani, F. Montazerifar, and A. K. Feizabad, "Study of oxidants and antioxidants in addicts," *International Journal of High Risk Behaviors and Addiction*, vol. 6, no. 2, 2017.

[11] E. Krošlák, T. Maliar, P. Nemecek et al., "Antioxidant and proteinase inhibitory activities of selected poppy (papaver somniferum L.) genotypes," *Chemistry & Biodiversity*, vol. 14, no. 9, Article ID e1700176, 2017.

[12] B. Bozan and F. Temelli, "Chemical composition and oxidative stability of flax, safflower and poppy seed and seed oils," *Bioresource Technology*, vol. 99, no. 14, pp. 6354–6359, 2008.

[13] Y. Yoshida, E. Niki, and N. Noguchi, "Comparative study on the action of tocopherols and tocotrienols as antioxidant: chemical and physical effects," *Chemistry and Physics of Lipids*, vol. 123, no. 1, pp. 63–75, 2003.

[14] B. D. Paul, C. Dreka, E. S. Knight, and M. L. Smith, "Gas chromatographic/mass spectrometric detection of narcotine, papaverine, and thebaine in seeds of Papaver somniferum," *Planta Medica*, vol. 62, no. 06, pp. 544–547, 1996.

[15] D. A. Güler, A. Aydın, M. Koyuncu, İ. Parmaksız, and Ş. Tekin, "Anticancer activity of papaver somniferum," *Journal of the Turkish Chemical Society, Section A: Chemistry*, vol. 3, no. 3, pp. 349–366, 2016.

[16] R. Demirgan, A. Karagoz, M. Pekmez et al., "In vitro anticancer activity and cytotoxicity of some papaver alkaloids on cancer and normal cell lines," *African Journal of Traditional, Complementary and Alternative Medicines*, vol. 13, no. 3, pp. 22–26, 2016.

[17] P. Momchev, P. Ciganović, M. Jug, E. Marguí, J. Jablan, and M. Zovko Končić, "Comparison of maceration and ultrasonication for green extraction of phenolic acids from echinacea purpurea aerial parts," *Molecules*, vol. 25, no. 21, p. 5142, 2020.

[18] J. i. Nakajima, I. Tanaka, S. Seo, M. Yamazaki, and K. Saito, "LC/PDA/ESI-MS profiling and radical scavenging activity of anthocyanins in various berries," *Journal of Biomedicine and Biotechnology*, vol. 2004, no. 5, pp. 241–247, 2004.

[19] F. W. McLafferty, D. B. Stauffer, E. Stenhagen, and S. R. Heller, *The Wiley/NBS Registry of Mass Spectral Data/Fred W. McLafferty, Douglas B. Stauffer*, Wiley, New York, NY, USA, 1989.

[20] A. A. Jabbar, "Onosma mutabilis: phytochemical composition, antioxidant, cytotoxicity, and acute oral toxicity," *Food Science & Nutrition*, vol. 9, no. 10, pp. 5755–5764, 2021.

[21] R. Bharadwaj, J. Haloi, and S. Medhi, "Topical delivery of methanolic root extract of Annona reticulata against skin cancer," *South African Journal of Botany*, vol. 124, pp. 484–493, 2019.

[22] R. K. Ahmad, K. F. Dizaye, and A. A. Al-Asady, "Cytotoxic effects of pistacia khinjuk seed extracts on different cell lines and its mitogenic effects on blood lymphocyte in vitro," *Cihan University-Erbil Scientific Journal*, vol. 4, no. 1, pp. 13–20, 2020.

[23] J. Seo, J. Lee, H. Y. Yang, and J. Ju, "Antirrhinum majus L. flower extract inhibits cell growth and metastatic properties in human colon and lung cancer cell lines," *Food Science & Nutrition*, vol. 8, no. 11, pp. 6259–6268, 2020.

[24] D. Twilley, L. Langhansová, D. Palaniswamy, and N. Lall, "Evaluation of traditionally used medicinal plants for anticancer, antioxidant, anti-inflammatory and anti-viral (HPV-1) activity," *South African Journal of Botany*, vol. 112, pp. 494–500, 2017.

[25] S. Cyboran-Mikołajczyk, Á. Csonka, J. Molnar, D. Szabó, J. Oszmiański, and H. Kleszczyńska, "In vitro studies of antihemolytic and cytotoxic activity of procyanidin-rich extract from the leaves of actinidia arguta," *Polish Journal of Food and Nutrition Sciences*, vol. 68, no. 2, pp. 171–177, 2018.

[26] F. Al-Rimawi, S. Rishmawi, S. H. Ariqat, M. F. Khalid, I. Warad, and Z. Salah, "Anticancer activity, antioxidant activity, and phenolic and flavonoids content of wild *Tragopogon porrifolius* plant extracts," *Evidence-Based Complementary and Alternative Medicine*, vol. 2016, Article ID 9612490, 7 pages, 2016.

[27] J. K. Achakzai, M. Anwar Panezai, M. A. Kakar et al., "Vitro anticancer MCF-7, anti-inflammatory, and brine shrimp lethality assay (BSLA) and GC-MS analysis of whole plant butanol fraction of *Rheum ribes* (WBFRR)," *BioMed Research International*, vol. 2019, Article ID 3264846, 8 pages, 2019.

[28] J. Concato and J. A. Hartigan, "P values: from suggestion to superstition," *Journal of Investigative Medicine: The Official Publication of the American Federation for Clinical Research*, vol. 64, no. 7, pp. 1166–1171, 2016.

[29] O. Bayazeid, E. Nemutlu, C. C. Eylem et al., "Neuroactivity of the naturally occurring aporphine alkaloid, roemerine," *Natural Product Research*, vol. 35, no. 24, 2020.

[30] M. A. Hijazi, M. Aboul-Ela, K. Bouhadir, M. Fatfat, H. Gali-Muhtasib, and A. Ellakany, "Alkaloids of Papaver libanoticum and their cytotoxic activity," *Records of Natural Products*, vol. 12, no. 6, pp. 611–618, 2018.

[31] O. Bayazeid, C. C. Eylem, T. Reçber, F. N. Yalçın, S. Kır, and E. Nemutlu, "An LC-ESI-MS/MS method for the simultaneous determination of pronuciferine and roemerine in some Papaver species," *Journal of Chromatography B*, vol. 1096, pp. 223–227, 2018.

[32] J.-X. Zhou, M. Braun, P. Wetterauer, B. Wetterauer, and M. Wink, "Antioxidant, cytotoxic, and antimicrobial activities of Glycyrrhiza glabra L., paeonia lactiflora pall., and eriobotrya japonica (thunb.) lindl. Extracts," *Medicines*, vol. 6, no. 2, p. 43, 2019.

[33] P. Sirikhansaeng, T. Tanee, R. Sudmoon, and A. Chaveerach, "Major phytochemical as γ-sitosterol disclosing and toxicity testing in lagerstroemia species," *Evidence-Based Complementary and Alternative Medicine*, vol. 2017, Article ID 7209851, 10 pages, 2017.

[34] A. Albeshri, N. A. Baeshen, T. A. Bouback, and A. A. Aljaddawi, "A review of rhazya stricta decne phytochemistry, bioactivities, pharmacological activities, toxicity, and folkloric medicinal uses," *Plants*, vol. 10, no. 11, pp. 2508–2518, 2021.

[35] H. J. Jafaar, O. Isbilen, E. Volkan, and G. Sariyar, "Alkaloid profiling and antimicrobial activities of Papaver glaucum and P. decaisnei," *BMC Research Notes*, vol. 14, no. 1, p. 348, 2021.

[36] X. Huo, "[Determination of thebaine in various tissues of papaver bracteatum by gas chromatography]," *Se Pu = Chinese Journal of Chromatography*, vol. 17, no. 1, pp. 70–72, 1999.

[37] J.-H. Oh, I. J. Ha, M. Y. Lee et al., "Identification and metabolite profiling of alkaloids in aerial parts of Papaver rhoeas by liquid chromatography coupled with quadrupole time-of-flight tandem mass spectrometry," *Journal of Separation Science*, vol. 41, no. 12, pp. 2517–2527, 2018.

[38] K. Li, X. Shi, X. Yang, Y. Wang, C. Ye, and Z. Yang, "Antioxidative activities and the chemical constituents of two Chinese teas, Camellia kucha and C. ptilophylla," *International Journal of Food Science & Technology*, vol. 47, no. 5, pp. 1063–1071, 2012.

[39] F. Sharopov, A. Valiev, I. Gulmurodov, M. Sobeh, P. Satyal, and M. Wink, "Alkaloid content, antioxidant and cytotoxic activities of various parts of papaver somniferum," *Pharmaceutical Chemistry Journal*, vol. 52, no. 5, pp. 459–463, 2018.

[40] C.-Y. Li, Y. H. Meng, Z. M. Ying et al., "Three novel alkaloids from portulaca oleracea L. And their anti-inflammatory effects," *Journal of Agricultural and Food Chemistry*, vol. 64, no. 29, pp. 5837–5844, 2016.

[41] A. Yücetepe, G. Altin, and B. Özçelik, "A novel antioxidant source: evaluation of in vitro bioaccessibility, antioxidant activity and polyphenol profile of phenolic extract from black radish peel wastes (Raphanus sativus L. var. Niger) during simulated gastrointestinal digestion," *International Journal of Food Science & Technology*, vol. 56, no. 3, pp. 1376–1384, 2021.

[42] C. C. Ikewuchi, J. C. Ikewuchi, and M. O. Ifeanacho, "Bioactive phytochemicals in an aqueous extract of the leaves of Talinum triangulare," *Food Science & Nutrition*, vol. 5, no. 3, pp. 696–701, 2017.

[43] S. Ishtiaque, N. Khan, M. A. Siddiqui, R. Siddiqi, and S. Naz, "Antioxidant potential of the extracts, fractions and oils derived from oilseeds," *Antioxidants*, vol. 2, no. 4, pp. 246–256, 2013.

[44] H. S. Chung and W. S. Woo, "A quinolone alkaloid with antioxidant activity from the aleurone layer of anthocyanin-pigmented rice," *Journal of Natural Products*, vol. 64, no. 12, pp. 1579-1580, 2001.

[45] K. Hasplova, A. Hudecova, E. Miadokova et al., "Biological activity of plant extract isolated from Papaver rhoeas on human lymfoblastoid cell line," *Neoplasma*, vol. 58, no. 5, pp. 386–391, 2011.

[46] N. Tena, J. Martín, and A. G. Asuero, "State of the art of anthocyanins: antioxidant activity, sources, bioavailability, and therapeutic effect in human health," *Antioxidants*, vol. 9, no. 5, p. 451, 2020.

[47] S. Selen Isbilir and A. Sagiroglu, "An assessment of in Vitro antioxidant activities of different extracts from Papaver rhoeas L. Leaves," *International Journal of Food Properties*, vol. 15, no. 6, pp. 1300–1308, 2012.

[48] J. Katarzyna, J. Karolina, K. Patrycja, B. Mateusz, and G. Izabela, "Mineral composition and antioxidant potential in the common poppy (papaver rhoeas L.) petal infusions," *Biological Trace Element Research*, vol. 199, no. 1, pp. 371–381, 2021.

[49] A. Trichopoulou, E. Vasilopoulou, P. Hollman et al., "Nutritional composition and flavonoid content of edible wild greens and green pies: a potential rich source of antioxidant nutrients in the Mediterranean diet," *Food Chemistry*, vol. 70, no. 3, pp. 319–323, 2000.

[50] C.-M. Liu, C. L. Kao, H. M. Wu et al., "Antioxidant and anticancer aporphine alkaloids from the leaves of *Nelumbo nucifera* Gaertn. cv. Rosa-plena," *Molecules*, vol. 19, no. 11, pp. 17829–17838, 2014.

[51] D. Muthna, J. Cmielova, P. Tomsik, and M. Rezacova, "Boldine and related aporphines: from antioxidant to antiproliferative properties," *Natural Product Communications*, vol. 8, no. 12, 2013.

[52] B. F. Bilková, A. Balážová, and M. Obložinský, "Biochemical aspect of production Plants., of secondary metabolites in opium poppy," *Farmaceutický Obzor*, vol. 75, no. 6, pp. 152–158, 2006.

[53] A. Shaghaghi, A. Alirezalu, E. Nazarianpour, A. Sonboli, and S. Nejad-Ebrahimi, "Opioid alkaloids profiling and antioxidant capacity of Papaver species from Iran," *Industrial Crops and Products*, vol. 142, Article ID 111870, 2019.

[54] S. N. Jimenez-Garcia, M. A. Vazquez-Cruz, R. G. Guevara-González, I. Torres-Pacheco, A. Cruz-Hernandez, and A. A. Feregrino-Perez, "Current approaches for enhanced expression of secondary metabolites as bioactive compounds

in plants for agronomic and human health purposes," *Polish Journal of Food and Nutrition Sciences*, vol. 63, no. 2, pp. 67–78, 2013.

[55] S. Morimoto, K. Suemori, J. Moriwaki et al., "Morphine metabolism in the opium poppy and its possible physiological function," *Journal of Biological Chemistry*, vol. 276, no. 41, pp. 38179–38184, 2001.

[56] P. Gao, X. Nie, M. Zou, Y. Shi, and G. Cheng, "Recent advances in materials for extended-release antibiotic delivery system," *The Journal of Antibiotics*, vol. 64, no. 9, pp. 625–634, 2011.

[57] S. Sundarraj, R. Thangam, V. Sreevani et al., "γ-Sitosterol from Acacia nilotica L. induces G2/M cell cycle arrest and apoptosis through c-Myc suppression in MCF-7 and A549 cells," *Journal of Ethnopharmacology*, vol. 141, no. 3, pp. 803–809, 2012.

[58] I. Bulduk and F. Taktak, "Isolation and characterization of antitumor alkaloid from poppy capsules (*Papaver somniferum*)," *Journal of Chemistry*, vol. 2013, Article ID 493870, 4 pages, 2013.

[59] B. Bharath, K. Perinbam, S. Devanesan, M. S. AlSalhi, and M. Saravanan, "Evaluation of the anticancer potential of Hexadecanoic acid from brown algae Turbinaria ornata on HT–29 colon cancer cells," *Journal of Molecular Structure*, vol. 1235, Article ID 130229, 2021.

[60] J. Liu, H. Zhou, L. Song et al., "Anthocyanins: promising natural products with diverse pharmacological activities," *Molecules*, vol. 26, no. 13, pp. 3807–3823, 2021.

[61] M. You, G. L. Silva, H. Chai et al., "(-)-Roemerine, an aporphine alkaloid from annona senegalensis that reverses the multidrug-resistance phenotype with cultured cells," *Journal of Natural Products*, vol. 58, no. 4, pp. 598–604, 1995.

[62] N. Sharma, K. Samarakoon, R. Gyawali et al., "Evaluation of the antioxidant, anti-inflammatory, and anticancer activities of Euphorbia hirta ethanolic extract," *Molecules*, vol. 19, no. 9, pp. 14567–14581, 2014.

[63] N. M. Saleh, M. G. El-Gazzar, H. M. Aly, and R. A. Othman, "Novel anticancer fused pyrazole derivatives as EGFR and VEGFR-2 dual TK inhibitors," *Frontiers in Chemistry*, vol. 7, p. 917, 202AD.

[64] A. Bishayee, P. A. Patel, P. Sharma, S. Thoutireddy, and N. Das, "Lotus (*Nelumbo nucifera* gaertn.) and its bioactive phytocompounds: a tribute to cancer prevention and intervention," *Cancers*, vol. 14, no. 3, p. 529, 2022.

[65] T. Winzer, V. Gazda, Z. He et al., "A Papaver somniferum 10-gene cluster for synthesis of the anticancer alkaloid noscapine," *Science*, vol. 336, no. 6089, pp. 1704–1708, 2012.

[66] A. A. Jabbar, F. O. Abdullah, K. K. Abdulrahman, Y. Galali, and A. S. Sardar, "Papaver decaisnei: GC-MS alkaloids profiling , in vitro antioxidant , and anticancer activity," *Research Square*, pp. 1–18, 2022.