Original Article:

Evaluation of Susceptibility and Resistance of Human Infectious Bacteria and Identification of Bioactive Compounds in *Pistacia atlantica*, *Cassia absus*, and *Quercus persica*

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ABSTRACT

Background: The antimicrobial activity of plants has long been considered an effective mechanism for controlling pathogenic microorganisms.

Objectives: This study aimed to identify phytochemical compounds of the seed extracts from ethnomedicinal plants of *Pistacia atlantica*, *Cassia absus*, and *Quercus persica* with Gas Chromatography-Mass Spectrometry (GC-MS) and investigation of their antibacterial and antioxidant activities.

Methods: The seeds were collected from Lorestan Province, Iran. Their antibacterial and anti-radical activities were analyzed by disk-diffusion and 2,2-diphenyl-1-picrylhydrazyl assays, respectively. Ethanol (96%), methanol (80%), and distilled water extracts were obtained by the maceration method. The methanol extract was used for the analysis of chemical compositions.

Results: About 40, 31, and 8 compounds were identified by GC-MS in the seeds of *C. absus*, *P. atlantica*, and *Q. persica*, respectively. Results indicated that 2,4-di-tert-butylphenol (36.043%) and tetradecanoic acid (4.92%) were dominated in the seed extracts of *C. absus*. However, germacyclopetene (38.119%) and 1,2,3-benzenetriol (8.115%) were dominated in the seed extracts of *P. atlantica*. Furthermore, 5H-tetrazole-5-thione, 1,4-dihydro-1,4-dimethy (38.505%), and tetradecanoic acid (30.546%) were dominated in the seed extracts of *Q. persica*. The highest inhibitory activity against *Micrococcus luteus* was observed on the methanol extract of *C. absus* with ascorbic acid. A significant difference was observed between the Inhibitory Concentration (IC50) values of methanol extract of *C. absus* with ascorbic acid.

Conclusion: Because of the presence of antimicrobial compounds in the tested ethnomedicinal plants, they can be used to synthesize new antimicrobial drugs in medicinal and pharmaceutical sciences.

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Introduction

Essential oils and plant extracts have antifungal, antibacterial, and cytotoxic activities [1]. Plants have been used for a thousand years as medicines for treating different diseases and medical complaints by most civilizations [2]. The advancement of pharmaceutical technology in the synthesis of chemical drugs and its widespread use has created the complex problem of side effects of drugs and resistance of pathogenic microorganisms against synthetic drugs. Secondary metabolites of medicinal plants have proved to be an excellent reservoir of new medicinal compounds [3] and directed scientists' attention to natural and herbal medicines [4].

Pistacia atlantica is a tree belonging to the Anacardiaceae family. The most important compounds in the gum of *P. atlantica* are turpentine oil and colophony. Turpentine is used as an herbicide and for the scent of soap, cleansers, and the production of wax [5]. Antibacterial activities of *P. atlantica*, *Pistacia chinensis*, and *Pistacia vera* leaf extracts have been reported [5-7]. The antimicrobial activity of *P. chinensis* leaves methanol extract was more against Gram-positive than Gram-negative bacteria [7]. Generally, the higher resistance of Gram-negative bacteria could be related to the presence of their outer phospholipid membrane [8]. The antimicrobial activity of *P. chinensis* leaves methanol extract could be related to the presence of triterpenes and flavonoids [9]. The antimicrobial activity of *P. lentiscus* essential oil against microorganisms has been reported [10, 11].

Cassia absus is an annual plant belonging to the Fabaceae family [12]. *C. absus* has various chemical compounds, including various oils and alkaloids, minerals such as calcium, iron, and zinc, and thiamine and riboflavin vitamins [13]. Seeds of *C. absus* are used as an astringent in the bowel and abdomen and treat ocular diseases [14]. Anticancer activity of methanol extracts of *Cassia fistula* on human prostate cancer cell line has also been reported [15]. The flowers of *C. singueana* have long been used to treat typhoid, malaria, respiratory tract infections and as an antiulcer, antispasmodic, and anti-inflammatory agent [13].

Quercus persica is a tree with leather leaves from the Fagaceae family. This family includes nine genera, of which three (*Fagus*, *Quercus*, and *Castanea*) grow in Iran [16]. Approximately 3 million hectares of Iran's forests are covered by various oak species, dominated by *Q. persica, Quercus infectoria*, and *Quercus libani*, mostly in the west of Iran [17]. The medicinal importance of *Quercus* trees is mainly related to the tannins in its leaves [18]. Antibacterial activity of leaf extracts from *Q. persica* and bioactivity of hydroalcoholic extract of *Quercus brantii* against palladium-induced oxidative stress in the male mice reproductive system has been proven [19].

Overall, the anticancer, antimicrobial, and antioxidant properties of plant extracts of *P. atlantica*, *C. absus*, and *Q. persica* have been reported. However, little or no work has been done on the seeds of these plants, which are growing in the western forests of Iran. Thus, this research aimed at the identification of *P. atlantica*, *C. absus*, and *Q. persica* seeds phytochemicals and also the evaluation of antibacterial and antioxidant activities of these plants in vitro.

Materials and Methods

Chemicals used

Nutrient Broth (NB), Mueller Hinton Agar (MHA) culture media, and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were purchased from Merck Co. (Darmstadt, Germany). Ciprofloxacin and gentamicin antibiotics were prepared from Paten Tab Co. (Tehran, Iran).

Preparation of plant extracts

The seeds of *Q. persica* var. *ovoidea*, *P. atlantica* subsp. *mutica* and *C. absus* var. *meonandra*, with respective herbarium numbers of 37228, 37227, and 37222, were collected from Lorestan Province, Iran. The samples were dried at room temperature under the shadow (Figure 1). The dried samples were broken into small pieces (2 mm) by a cylindrical crusher [20]. Ethanol (96%), methanol (80%), and distilled water extracts were obtained by the maceration method [21]. Accordingly, 25 g of dried powder was separately added to a volume of 250 mL of used solvents. The extracts were filtered through filter paper and centrifuged at 10000 rpm for 8 min [22]. The extract was evaporated by rotary and was transferred to an oven at 37˚C for complete drying. The residues were stored in the dark at -22˚C [23].

Tested bacterial strains

All bacteria were obtained from Tehran University of Medical Sciences, Iran. The antibacterial activity of the extracts was tested in vitro against the Gram-positive bacteria of *Streptococcus pyogenes* (PTCC-1447), *Bacillus subtilis* (PTCC-1156), *Bacillus cereus* (PTCC-1247), *Micrococcus luteus* (ATCC 10987), *Enterococcus faecalis* (PTCC-1195), and *Staphylococcus aureus* (PTCC-1189)

Figure 1. *Quercus persica* var. *ovoidea, Pistacia atlantica* subsp. *mutica* , and *Cassia absus* var. *meonandra*

as well as the Gram-negative bacteria of *Escherichia coli* (ATCC-25922), *Shigella boydii* (PTCC1744), *Salmonella typhi* (PTCC-1609), *Pseudomonas aeruginosa* (PTCC-1181), *Enterobacter aerogenes* (PTCC-1221), *Proteus mirabilis* (PTCC-1287), *Neisseria meningitides* (PTCC-4578), *Acinetobacter baumannii* (PTCC-4413), and *Klebsiella pneumoniae* (PTCC-1129). To prepare fresh bacterial cultures, a bacterial colony was transferred to MHA medium and incubated for 24 h at 37°C. Then a loop of the bacterial colony was transferred to NB medium and was incubated at 37˚C for 18 h [24]. The turbidity of suspension was adjusted to an equivalent of 0.5 McFarland standards (1.5×10^8 CFU).

Disk diffusion test

The antibacterial activity of plant extracts was done by disk diffusion test [25]. The ethanol (96%), methanol (80%), and distilled water extract (200 mg/mL) from *Q. persica*, *P. atlantica*, and *C. absus* seeds were prepared. A volume of 250 µL bacterial suspension (1.5×10^8 CFU) was poured onto the MHA medium and spread. A volume of 50 µL of the extract was poured on disks. Petri plates were incubated at 37˚C for 24 h [4]. Gentamicin (10 µg) and ciprofloxacin (0.005 µg) were used as positive controls [26]. The inhibitory zone around disks was measured (cm).

Determination of DPPH for free radical scavenging activity

The free radical activity was investigated according to the Stojicevic et al. [27] method. Different concentrations (0.2, 0.4, 0.6, 0.8, and 1 mg/mL) of methanol extract from *Q. persica*, *P. atlantica*, and *C. absus* seeds were prepared, and ascorbic acid was used as a reference standard. The samples were placed in darkness for 30 min, and then solvent absorption was recorded by spectrophotometer at 517 nm. The methanol (99%) was used as the blank. The Formula 1 calculated the free radical scavenging activity (%):

1. Radical scavenging activity (%)= 100(1 - (As - Ab)/Ac

, where As refers to the sample, Ab denotes blank, and Ac refers to control.

Gas chromatography-mass spectrometry

Gas Chromatography coupled with Mass Spectrometry (GC-MS) was applied to analyze the chemical compositions of the seeds methanol extracts (Tehran University, Iran). The GC-MS analysis was carried out using an Agilent 6890N coupled to Agilent 5973 mass detector, with HP-5, 30 m (length) × 0.25 mm (ID) × 0.25 µm column. The instrument was set to an initial temperature of 55˚C and maintained at this temperature for 2 min. The temperature was increased to 120°C, at the rate of 8°C/min and then to 200°C, at the rate of 3.5°C/min. Injection port temperature was ensured as 350°C and helium flow rate as 0.9 mL/min. The samples were injected in split/splitless mode. Solvent delay adjusted for 5 min, and 0.5 µL volume was injected.

Statistical analysis

The experiments were performed in a completely randomized design with a factorial test. The average comparison was analyzed by the Duncan test at $P<0.05$ in SPSS version 16.

Results

The methanol extract compounds of *C. absus, P. atlantica and Q. persica* seeds were determined by GC-MS. About 40, 31, and 8 compounds were identified in *C. absus, P. atlantica and Q. persica*, respectively. The dominant chemicals in *C. absus* included 2,4-di-tert-butylphenol (36.043%), tetradecanoic acid (4.92%),

Table 1. The seed chemical compositions of *C. absus, P. atlantica and Q. persica,* identified by gas chromatography-mass spectroscopy

C. absus	Compound Content (%)	*P. atlantica*	Compound Content (%)	*Q. persica*	Compound Content (%)
Bicyclo[4.2.0]octa-1,3,5-triene	1.407	cis- 2,2,4,6-Tetramethyl-1,3-oxathiane	0.662	3-Hepten-2-one, 3-methyl-	5.065
Cumene	1.766	(Z)- 3,4-dimethyl- 2-Pentene	0.288	5-Hydroxymethylfuraldehyde (HMF)	5.194
Benzene, propyl-	0.521	3-methyl-2,5-Furandione	1.100	Trans-1,3-dihydroxy-cyclopentane	3.588
Undecane, 5-methyl-	1.175	5-Methylfurfural	0.526	5H-Tetrazole-5-thione, 1,4-dihydro-1,4-dimethyl-	38.505
Phloroglucine	0.698	n-butylthiophene	1.925	2-phenylcyclohexanone	5.914
4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	1.255	Butyric acid	2.169	Tetradecanoic acid	30.546
Undecane 2,4-dimethyl	1.305	Thretol	1.871	Nonahexacontanoic acid	1.557
Dodecane	1.035	2-Methoxytetrahydropyran	1.034	Benzyl (dideuterated) methyl ether	9.631
Decane, 2,3,7-trimethyl-	1.017	5-methyl-2-Pyrazinyl methanol	1.091		
Tetradecane	0.584	Thymine	3.876		
Tridecane	0.863	2-Cyclohexene-1-ol	4.701		
1-Dodecanamine, N,N-dimethyl-	1.801	Amyl isovalerate	1.283		
2-Octanone	0.573	4H2,3-dihydro-3,5-dihydroxy-6-methyl-Pyran-4-one	3.382		
2,4-Di-tert-butylphenol	36.043	5-phenylpyrazole	1.308		
2,6-Dimethyl-3-(methoxymethyl)-p-benzoquinone	2.860	3(2-Hydroxlethyl)-1,2-ethylidene glycerol	2.175		
1,5-Heptadien-4-one, 3,3,6-trimethyl-	3.531	5-Hydroxymethylfuraldehyde (HMF)	5.815		
Hexadecane	1.512	2-propyl thiophene	2.812		
Docosane	1.096	2-methyl- 2-Heptenal	0.917		
Pentadecane, 2,6,10-trimethyl-	0.690	Methyl 2-Methyl-2-butenyl Ether	1.226		
Docosane	0.818	Phthalic anhydride	1.720		
Hexadecane, 2,6,10,14-tetramethyl-	0.616	1,3-Dithiolane, 2-(1-propenyl)	0.373		
Eicosane	3.528	2-methyl naphthalene	2.241		
Pentadecane	0.961	Para-menthadione	0.660		
Hexacosane	0.562	Octanoic acid	0.107		
Undecane, 3,5-dimethyl	0.669	1,2,3-Benzenetriol	8.115		
Heneicosane	2.552	4-Hydroxy-2-methylpyrrolidine-2-carboxylic acid	4.319		

C. absus	Compound Content (%)	*P. atlantica*	Compound Content (%)	*Q. persica*	Compound Content (%)
Heptadecane	0.584	Dicyclohexyl ether	3.309		
Tetradecanoic acid	4.924	Germacyclopetene	38.119		
Octadecane	1.129	2-methyl-2-Penten-1-ol	0.615		
Octadecane	0.771	Tetradecanoic acid	1.414		
p-Dioxane hydroperoxide	0.654	Hexadecanoic acid, methyl ester	0.845		
Hexadecane, 3-methyl	2.988				
Pentatriacontane	1.996				
Tridecane	1.461				
Tetradecane 2-methyl	2.727				
Nonadecane	1.423				
Triacontane	4.102				
Hexadecanoic acid, methyl ester	3.584				
Octacosane	3.558				
Hexadecane, 2,6,10,14-tetra-methyl	0.663				

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triacontane (4.102%), hexadecanoic acid (3.58%), octacosane (3.55%). However, the dominant chemicals in *P. atlantica* included germacyclopetene (38.119%), 1,2,3-benzenetriol (8.115%), 5-hydroxymethylfuraldehyde (HMF) (5.815%) and 2-cyclohexene-1-ol (4.701%). The most compounds found in *Q. persica* were 5H-tetrazole-5-thione, 1,4-dihydro-1,4-dimethy (38.505%), tetradecanoic acid (30.546%), benzyl (dideuterated) methyl ether (9.631%), and 2-phenylcyclohexanone (5.914%) (Table 1).

Antibacterial activity

The inhibitory activity of alcoholic and aqueous extracts of *C. absus*, *P. atlantica*, and *Q. persica* was evaluated against some human pathogenic bacteria in vitro (Table 2). Negative control (50 µL of used solvents) and positive controls (gentamicin and ciprofloxacin) were included. After incubation, the bacterial growth zone of inhibitions (diameter) around the wells was measured. The methanol extract of *C. absus* showed the highest inhibitory activity against *M. luteus*. The methanol extract had a more inhibitory effect than ethanol and aqueous extracts. Furthermore, *E. coli* and *E. aerogenes* had resistance against all extracts. The Gram-negative bacteria, including *P. mirabilis* and *N. meningitides* showed susceptibility on all of the tested extracts. Results indicated that the Gram-positive bacteria had more susceptibility than Gram-negative bacteria. *S. pyogenes* had resistance against ethanol and aqueous extracts of *Q. persica*. The inhibitory activity of *C. absus* methanol extract on *B. cereus* and *M. luteus* was more potent than gentamicin. In total, *C. absus* extracts showed a greater inhibitory effect than *P. atlantica* and *Q. persica* extracts (Table 2).

Antioxidant activity

As seen in Table 3, the amount of DPPH free radicals inhibition was increased by increasing the concentration of plant extracts. A significant difference was observed between the IC50 values of methanol extract of *C. absus* compared with ascorbic acid as the control (Table 3). The methanol extract of *C. absus* showed weak radical scavenging activities.

Table 2. Antibacterial activity of different extracts of C. absus, P. atlantica, and Q. persica in comparison to gentamicin and ciprofloxacin

Bacteria	*Q. persica*			*P. atlantica*			*C. absus*			Gentamicin	Ciprofloxacin
	Methanol	Ethanol	Aqueous	Methanol	Ethanol	Aqueous	Methanol	Ethanol	Aqueous		
B. subtilis	14±0.2	12.5±0.33	10±0.88	14.5±1.2	12±0.33	9.5±0.88	18±0.33	16.5±0.33	13±0.57	29±0.57	29.5±0.33
B. cereus	16±0.33	15.6±1.2	9±0.33	15.8±0.33	14.5±0.22	8.5±0.57	20±0.33	17±0.57	10.5±0.88	19.66±0.33	28.5±0.66
S. aureus	13.5±0.33	12±0.88	9±0.33	15±0.33	14.6±0.88	7.5±0.88	17±0.57	16.5±0.88	10.5±0.33	20±1	28.5±0.66
S. pyogenes	12.8±0.33	-	-	13.5±0.88	12±0.57	-	16±0.33	15.5±0.88	9.4±0.57	20±0.57	31.5±0.33
M. luteus	14±0.33	13.5±0.57	10±0.57	16±0.33	15.5±0.22	9.3±0.33	24±0.33	18.2±0.57	12±0.88	22±0.33	30±1
E. faecalis	12±0.88	11±0.33	-	11.2±0.33	10±0.57	-	14.5±0.33	10±0.33	7±0.33	16±0.33	17.5±0.57
S. boydii	11±0.33	-	-	11.5±0.57	11±0.22	-	13.5±0.57	11±0.88	8±0.22	19±0.57	37.5±0.66
P. aeruginosa	-	-	-	-	-	-	8.5±0.57	8±0.22	-	20±0.33	24.5±0.66
E. coli	-	-	-	-	-	-	-	-	-	19.5±1	24.5±0.57
E. aerogenes	-	-	-	-	-	-	-	-	-	11±0.33	28±0.33
P. mirabilis	10.4±0.33	9±0.22	8±0.57	10±0.57	10±0.33	8.5±0.33	12±0.33	12±0.57	7.5±0.88	15±0.33	17±0.57
N. meningitides	12.6±0.33	11.3±0.57	7±0.22	14±0.33	12..5±0.2	9.5±0.57	13.5±0.33	11±0.88	8.2±0.22	16.5±0.88	17.5±0.88
A. baumannii	-	-	-	10±0.33	8±0.88	-	9.5±0.57	-	-	15±0.88	16±0.33
K. pneumoniae	12.5±0.33	10±0.33	-	12±0.22	-	-	15±0.22	12±0.33	7±0.33	15±0.57	16.5±0.57
S. typhi	-	-	-	15±0.33	13.5±0.88	10±0.33	16±0.22	14±0.88	8.6±0.88	29.5±1	33±0.57

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Discussion

In recent years, several antibiotics have lost their effectiveness due to the development of resistant strains, mainly through the expression of resistance genes. Therefore, there is a need to develop alternative antimicrobial drugs from various sources, such as medicinal plants [28]. The antibacterial and antioxidant activity from 2,4-di-tert-butylphenol and the antioxidant, hypocholesterolemic, nematicide, pesticide, lubricant, and hemolytic inhibitor from hexadecanoic acid have been proven [29]. The 9-octadecanoic acid is a saturated fatty acid and has exhibited antimicrobial activity [30]. The human epidemiological studies have shown that tetradecanoic acid was the saturated fatty acid that is strongly related to the average serum cholesterol concentrations in humans [31].

C. fistula has been used as an Ayurvedic cure to treat heart disease, hematemesis, pruritus, leucoderma, abdominal lump, metabolic disorder, and purgative [32]. The anti-inflammatory, antioxidant, antimicrobial, wound healing properties, and anticancer activity on MCF-7 and SiHa cell lines of *C. fistula* has been reported [33]. The antioxidant activity of leaf hexane extract of *C. fistula* was increased by higher concentration [34]. The seed methanol extract of *C. auriculata*, *C. absus*, and *C. fistula* showed higher radical scavenging activity than ethyl acetate and hexane extracts [35], which was similar to our results. The methanol extract of *Cassia fistula* against *S. faecalis* showed a more inhibitory effect [36]. The results of this group, probably due to differences in the type of species and climate condition, are different from our results. The chemical compositions of *C. fistula* flower extract were identified as 4-dihydroxy-1-methoxyanthracene-9, 10-dione, methyl-16-ethylheptadecanoate, butyl hexadecanoate or butyl palmitate, parietin, methyl undecanoate, tetradecanoic acid, rhein, and butyl 2-butoxyhexadec-4-ynoate [37]. The tetradecanoic acid found in mentioned species was similar to our results. The chemical agents, including citronellol (17.24), isophytol (17.24), phytol (17.24), and linolenic acid (17.17), were identified from the methanol extract of *C. fistula* [15], which was not similar to our research. Some factors, such as plant species, organ types, ex-

Table 3. Antioxidant activity (IC50: mg/mL) of *C. absus*, *P. atlantica*, and *Q. persica*, and inhibition percentage of DPPH

Sample	Inhibition Percentage of DPPH in Different Concentrations (mg/mL^{-1})					IC50
	0.2	0.4	0.6	0.8	1	
C. absus	82.83	93.11	96.02	97.07	98.07	0.1207[a]
P. atlantica	89.77	92.39	93.43	96.98	99.74	0.1113[b]
Q. persica	91.72	93.52	94.52	96.87	98.17	0.1090[b]
Ascorbic acid	91.3	92.43	97.41	98.56	99.67	0.1090[b]

The same letters are not significantly different at P<0.05.

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tract solvents, time and stage of growth, and environmental conditions, are effective in the type and percentage of extracted compounds. The presence of 2-hydroxyethylhydrazine, phytol, n-hexadecanoic acid, oleic acid, cyclotrisiloxane, hexamethyl, di-ndecylsulfone alkaloids, anthraquinones, saponins, phenols, tannins, flavonoids, and terpenoids was confirmed in the leaves hexane extract of *C. fistula* [34]. Kuo et al. [38] reported oxyanthraquinones, chrysophanol, and chrysophanein in *C. fistula* seeds. Seeds and leaves of *Cassia tora* are used to treat itch, ringworm, and other skin diseases.

The *P. atlantica* is used for the treatment of peptic ulcers [39]. The essential seed oil of *P. chinensis* is used for biodiesel production in China [40]. Antimicrobial activity of Pistacia species leaf extract against some plant pathogenic has been reported [5]. According to Mohammadi-Sichani et al. [41], the highest antibacterial activity and the minimum inhibitory concentration were observed from gall methanol extract. The compounds of β-sitosterol, luepol, flavonoids, quercetin, myricetin, quercetin 3-O-α-rhamnoside, quercetin 3-O-β-glucoside, myricetin 3-O-α-rhamnoside, and myricetin 3-O-β-glucuronide were identified in the leaves methanol extract of *P. chinensis* [7]. The antioxidant activity of quercetin has been proven and is used as a standard for the evaluation of secondary metabolites such as phenols and flavonoids [3]. The chemical compositions, including myrcene (19%-25%), a-pinene (16%), terpinen-4-ol (22%), d-3-carene (65%), myrcene, limonene, terpinen-4-ol, a-pinene, b -pinene, α -phellandrene, sabinene, para-cymene, and γ-terpinene were analyzed from *P. atlantica* essential oil [42].

The antibacterial activity of *Q. persica* ethanol extract has been reported [43]. The gall extracts of *Q. infectoria* have antibacterial, antiviral, antifungal, and anti-inflammatory activities [44]. The most susceptible and resistant bacteria were *S. epidermidis* and *E. coli*, respectively, against *Q. persica* extract [45]. These findings were similar to our results about *E. coli.* Hussein et al. [46] determined the phytochemical compounds of cis-p-mentha-1(7), 8-dien-2-ol,3-Nonynoic acid, urea, N,N′-bis(2- hydroxyethyl)-, 3-trifluoroacetoxypentadecane, Pterin-6-carboxylic acid, 2,2-difluoroheptacosanoic acid, γ-sitosterol, spirost-8-en-11-one, 3-hydroxy in the gall methanol extract of *Q. infectoria*. These compounds, due to differences in species and organ types, were not similar to our results. Plants are the richest sources of secondary metabolites with various biological activities. Accordingly, differences in species and genus, extract, solvent, and different geographical locations, time and climate conditions, and so on could affect the type and content of extracted compounds and their antibacterial activities.

Conclusion

The chemical compositions of *C. absus, P. atlantica and Q. persica* were identified from seeds methanol extract by GC-MS. The mentioned plant extracts showed antibacterial activity against some human infectious bacteria in vitro. Also, the antioxidant activity and IC50 value were investigated in different extracts. Based on the findings, the extract compounds of *C. absus*, *P. atlantica*, and *Q. persica* seeds can be used to synthesize antibacterial drugs in pharmaceutical and medicinal science against some human pathogenic bacteria.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Both authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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