ABSTRACT
Extracts from the wood of *Juniperus excelsa* ssp. *polycarpos* were analysed for their antioxidant activity using the DPPH method and compared with ascorbic acid and butylated hydroxytoluene. The most active extracts were analysed for their chemical composition using gas chromatography–mass spectrometry. Acetone extract was found to be moderately active as an antioxidant agent at 58.38%, which was lower than the value of vitamin C (98.56%) at the concentration of 14.20 mg/mL. The major components identified in the acetone extract as trimethylsilyl (TMS) derivatives were pimaric acid TMS (24.56%), followed by α-D-glucopyranoside,1,3,4,6-tetakis-O-(TMS)-β-D-fructofuranosyl 2,3,4,6-tetrakis-O-(TMS) (21.39%), trifluoromethyl-bis-(TMS) methyl ketone (9.32%), and cedrol (0.72%). The dissolved water:methanol (1:1 v/v) partitioned from acetone extract afforded 12 fractions; among them, the F9 fraction was found to have good antioxidant activity (88.49%) at the concentration of 14.20 mg/mL. The major compounds identified in F9 fraction were α-D-glucopyranoside, 1,3,4,6-tetakis-O-(TMS) (20.22%) and trifluoromethyl-bis-(TMS)methyl ketone (5.10%).

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1. Introduction

Persian juniper (*Juniperus excelsa* ssp. *Polycarpos*) is a dioecious tree up to 6–7 m tall or a low shrub with dense head (Emami et al. 2011), also widely distributed in other areas such as south-east Arabia, Iran, Caucasus, Baluchistan, Afghanistan, north-west Himalaya (Townsend & Guest 1966) Armenia, India, Uzbekistan, and Pakistan (Franco 1964).

Phenolics characterization of *Juniperus* sp. have been highlighted the presence of phenolic compounds including flavonoids, neolignans and phenylpropanoids (Nakanishi et al. 2004; Iida et al. 2007; Innocenti et al. 2007), also terpenoids (Okasaka et al. 2006; Nuñez et al. 2007). Two eudesmanes, two abietanes, two podocarpanes, and other nine known compounds (cedrol, 12,15-dihydroxylabda-8(17),13-dien-19-oic acid, hinokiflavone, (–)-2,3-dihydro-7-hydroxy-3-hydroxymethyl-2-(4′-hydroxy-3′-methoxyphenyl)-5-benzofuranopropanol-4′-O-a-L-rhamnopyranoside, 2,3-dihydrobenzofuran-2-(4′-hydroxy-3′-methoxyphenyl)-3-a-L-rhamnopyranosyloxy-methyl-7-methoxy-5-propanol, icaride E4′ (7S,8S)-3-methoxy-3′,7-epoxy-8,4′-oxyneoligna-4,9,9′-triol and cedrusin) were isolated from the dried fruits of *Juniperus polycarpus* var. *seravschanica* (Okasaka et al. 2006). The main compounds in the oils of leaves and fruits were α-pinene, 1,4-cineol, and limonene. However β-pinene was also one of the major components of *J. excelsa* subsp. *Polycarpos* leaves of female tree oil (Emami et al. 2011).

The extracted compounds of different types of *Juniperus* and their antibiotic activities have been expressed (Angioni et al. 2003; Filipowicz et al. 2003). The potential uses of the extracted compounds are in clued, aromatherapy, fragrance, soup, candle, lotions, and cosmetics materials (Yesenofski 1996).

The studies indicated that pentadecanoic acid, hexadecanoic acid, oleic acid, linoleic acid, and p-1isopropyl phenyl are the main extracted compounds of internal and the external wood, root and the stalk of *Juniperus foetidissima* in Turkey (Tunalier et al. 2003). 4-methyl-3-methoxy-3H-benzofuran-2-one, 4,9(α)-dihydroxy-nardosin-6-en, and 15-hydroxy-8(17),13(E)-labdadiene-19-carboxilic acid were isolated from the acetone extract of *J. foetidissima* leaves and branchlets (Rafieian-Kopaei et al. 2015). In vitro, the antioxidant activity of essential oils from different juniper berry species has been established (Emami et al. 2007).

Recent studies also indicated that the inhibitory effects of the extracted compounds were registered in various types of pathogenic fungi and similar micro-organisms (Soković et al. 2004). The largest compound in the fruit cones of *Juniperus communis* were terpenes (32.1%) which is used to treat indigestion, and also as disinfectant in dyspepsia as well as some other antibiotic effects (Lamparsky & Klime 1985).

Cedrol was found in the essential oil of *Conifers*, especially in the genera *Cupressus* and *Juniperus* (Connolly & Hill 1991). Its main uses are in the chemistry of aroma compounds (Breitmaier 2006). Result of Lindh et al. (2015) studies suggested that cedrol strongly attracts pregnant female mosquitoes after to create cedrol-baited traps. Sabinene was the most abundant compound in *Juniperus thurifera* L. var. Africana oils from the dried leaves and the oil had good antibacterial activities (Bahri et al. 2013). α-pinene, germacrene α, myrcene, abietadiene, and cis-calamenene were the main chemical composition of essential oil from *Juniperus oxycedrus* ssp. *macrocarpa* (S. & m.) Ball. and *Juniperus oxycedrus* L. ssp. *rufescens* (L. K.) berries and showed good antioxidant capacity (Hanène et al. 2012). Fatty acids and their methyl ester such as hexadecanoic and octadecanoic acids are relatively common essential oils in higher plants (Shabi et al. 2010). *Juniperus* has high resistance against wood
eating pests; humidity has no effect on it. The scent extracted from the tree also repels snakes and scorpions and other blood sucking insects (Zargari 1983).

In the present study, for the first time, the aim was firstly, to assess in vitro antioxidant activity of wood extracts from *J. excelsa* ssp. *polycarpos* with voucher specimen number 1893, and secondly to analyse the chemical composition of the extracts by GC/MS.

2. Results and discussion

2.1. Antioxidant activity

Statistically, there were significant differences among the treatments (F1 to F12, water:methanol, *n*-hexane, acetone, butylated hydroxytoluene (BHT), vitamin C and their concentrations (Table S1). The lowest antioxidant activity (22.25%) was observed at the concentration of 0.44 mg/mL, which was lower than the antioxidant activity value of vitamin C (60.66%) at the same concentration. The moderate activity came from acetone extract (53.98%) at 14.20 mg/mL, which was lower than the antioxidant activity value of vitamin C (98.56%) at the same concentration (Table S2). The same trend was observed with the reference (BHT). Emami et al. (2011) reported that the essential oils from various parts of both *J. excelsa* subsp. *polycarpos* and *Juniperus excelsa* subsp. *excels* species had relatively low antioxidant activity, but these activities suggested the possible uses of these essential oils in very low concentrations for preserving food materials.

Additionally, among the assayed fractions, F3 and F9 showed high antioxidant activity at 75.30 and 88.49%, respectively, when the concentration was 14.20 mg/mL. Looking at Figure S1, the following order showed the antioxidant activity; Vitamin C > F9 > F3 > BHT > F4 > F10 > F5 > F6 > water:methanol > acetone > *n*-hexane > F2 > F1 and the fraction (F9) retains an antioxidant activity comparable to acetone fraction.

2.2. Wood extract

Acetone extract of the fresh wood of *J. excelsa* ssp. *polycarpos* afforded 12% (v/w) in yield. Seventeen compounds of trimethylsilyl (TMS) derivatives were identified (Table S3).

The major components of acetone wood extract were pimaric acid TMS (24.56%), α-**D**-glucopyranoside,1,3,4,6-tetrakis-O-(TMS)-β-**D**-fructofuranosyl 2,3,4,6-tetrakis-O-(TMS) (21.39%), galactopyranose,1,2,3,4,6-pentakis-O-(TMS)-β-**D**- (12.10%), **D**-glucose,2,3,4,5,6-pentakis-O-(TMS) (11.30%), **D**-fructose,1,3,4,5,6-pentakis-O-(TMS) (9.97%), trifluoromethyl-bis-(TMS)methyl ketone (9.32%), and **β**-**D**-galactofuranose,1,2,3,5,6-pentakis-O-(TMS) (1.57%).

The other minor identified compounds were TMS derivatives of fatty acids such as hexadecanoic acid, TMS ester (0.78%), 9,12-octadecadienic acid (Z,Z), TMS ester (0.46%), oleic acid, TMS ester (0.34%), and octadecanoic acid, TMS ester (0.27%).

Among the identified components, two components (9.32, 0.63%) were ketone, three components (0.78, 0.46, 0.18%) were saturated fatty acid ester, one component (0.72%) was alcohol sesquiterpene, one component (0.45%) was glycerol, two components (0.34, 0.27%) were unsaturated fatty acid ester, three components (2.17, 2.03, 0.30%) were alkyl, and five components (21.39, 12.10, 11.30, 9.27, 1.57%) were sugar compounds. Cedrol has been reported in the extracts of *J. polycarpos* var. *seravschanica* (Joseph-Nathan et al. 1984; Okasaka et al. 2006).
Thirteen identified compounds in F9 fraction of J. excelsa ssp. polycarpos wood extracts were TMS derivatives (Table S4). The major compounds were α-D-glucopyranoside, 1,3,4,6-tetrakis-O-(TMS) (20.22%), D-glucose, 2,3,4,5,6-pentakis-O-(TMS) (9.05%), trifluoromethyl-bis-(TMS) methyl ketone (5.10%), glucopyranose, 1,2,3,4,6-pentakis-O-(TMS) (4.93%), β-D-galactofuranose, 1,2,3,5,6-pentakis-O-(TMS) (2.81), and TMS ether of glycerol (1.83%).

3. Conclusion

The chemical composition and antioxidant activity of extracts from the wood of J. excelsa ssp. polycarpos were reported for the first time.

The major components of acetone wood extract were pimaric acid TMS, α-D-glucopyranoside, 1,3,4,6-tetrakis-O-(TMS)-β-D-fructofuranosyl 2,3,4,6-tetrakis-O-(TMS), galactopyranose, 1,2,3,4,6-pentakis-O-(TMS)-β-D-glucose, 2,3,4,5,6-pentakis-O-(TMS), D-fructose, 1,3,4,5,6-pentakis-O-(TMS), and trifluoromethyl-bis-(TMS)methyl ketone. The major compounds from the fraction (F9) afforded from water:methanol extracts of J. excelsa ssp. polycarpos wood were α-D-glucopyranoside, 1,3,4,6-tetrakis-O-(TMS), D-glucose, 2,3,4,5,6-pentakis-O-(TMS), trifluoromethyl-bis-(TMS)methyl ketone, and glucopyranose, 1,2,3,4,6-pentakis-O-(trimethylsilyl). Results showed that juniper wood extracts are potential antioxidant agents.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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