Essential oils of whole tree, trunk, limbs and leaves of *Juniperus osteosperma* from Utah

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ABSTRACT

Volatile oil produced through steam distillation of *Juniperus osteosperma* was examined to establish essential oil yields and aromatic profiles from the whole juniper tree as well as each portion of the tree, namely the trunk, limbs, and leaves. The whole tree aromatic profile is abundant in α-pinene (40.5%), sabinene (4.7%), ρ-cymene (2.7%), limonene (4.2%), camphor (6.7%), bornyl acetate (6.7%), cis-thujopsene (5.6%), and cedrol (2.9%). Trunk essential oil is prominent in α-pinene (59.4%), δ-3-carene (4.4%), cis-thujopsene (11.0%) and cedrol (3.0%). Limb essential oil is prominent in α-pinene (85.3%) and cis-thujopsene (1.3%). Leaf essential oil, in agreement with previous findings, was composed primarily of lighter fractions, prominent in camphor (28.3%) and bornyl acetate (15.8%). The greatest yield (w/w) is from the leaf material (0.8%), followed by the whole tree (0.3%). The trunk (0.1%) and limbs (0.1%) provide the lowest yields. Published on-line www.phytologia.org *Phytologia 101(3): 188-193 (Sept 21, 2019).* ISSN 030319430.

KEY WORDS: *Juniperus osteosperma*, aromatic profile, essential oil, trunk, limbs, leaves, yield.

The genus *Juniperus* consists of nearly 75 species (Adams and Schwarzbach, 2013, Adams 2014). *Juniperus osteosperma* (Torr.) Little is a one-seeded, serrate leaf margined juniper (Adams et al., 2006) that has a widespread distribution throughout Utah, found in all counties in the state (Welsh, 1993).

The essential oil profile for *J. osteosperma* heartwood was previously established as being prominent in cis-thujopsene and cedrol (Adams, 1987) and leaf oil being prominent in camphor and bornyl acetate (Adams, 2012), with a significant degree of observed profile variation in the leaf oil. The latter study determined that differences in leaf essential oil profile were likely associated with geographic location. Commercially available whole tree *J. osteosperma* essential oil from Young Living Essential Oils, the sole producer, is produced from chipped plant material consisting of trunk, limb, and leaf parts distilled together.

The present study establishes the aromatic profile for whole tree, trunk, and limb essential oils and confirms previously established aromatic profiles for leaf essential oils of *J. osteosperma*. Essential oil yields for the whole tree and each portion of the tree are also examined.

MATERIALS AND METHODS

Juniperus osteosperma plant material was collected from ten locations, one tree per site, throughout the state of Utah. Samples collected were from trees with approximate dimensions of 4 m height, 4 m width (foliage), and 0.25 m diameter (trunk). For leaf material, approximately 100 g total was cut from four sides of the tree, approximately 2 m above the ground. A single whole tree was cut down in order to obtain samples of trunk, limbs, and leaves. The trunk is defined as a 0.25 m section (0.25-0.5 m above ground) including heartwood, sapwood, cambium, and bark. The limb is defined as leafless, 3-5 cm diameter sections nearest the trunk, approximately 2 m above ground. Voucher samples are held in the

Utah Valley University Herbarium (UVSC): *J. osteosperma* (Torr.) Little, Wilson 2018-01, -02, -03, -04, -05, -06, -07, -08, -09, -10 (UVSC).

Samples of whole tree (n=1), trunk (n=1), limb (n=1), and leaf (n=10) of *J. osteosperma* were processed as follows for laboratory scale distillation: each mentioned portion of the tree was cut, chipped, stored at ambient temperature out of direct sunlight, and steam distilled within 24 hours.

Laboratory scale distillation was as follows: 3 L of water added to the bottom of a 12 L distillation chamber (Albrigi Luigi S.R.L., Italy), plant material accurately weighed and added to the distillation chamber, distillation for 4 hours by direct steam, essential oil separated by a cooled condenser and Florentine flask. Essential oil samples were filtered and stored in a sealed amber glass bottle until analysis.

Essential oils were analyzed, and volatile compounds identified, by GC/MS using an Agilent 7890B GC/5977B MSD and J&W DB-5, 0.25 mm x 60 m, 0.25 µm film thickness, fused silica capillary column. Operating conditions: 0.1 µL of neat sample, 150:1 split ratio, initial oven temperature of 40 °C with an initial hold time of 5 minutes, oven ramp rate of 4.5 °C per minute to 310 °C with a hold time of 5 minutes. Volatile compounds were identified using the Adams volatile oil library (Adams, 2007) using Chemstation library search in conjunction with retention indices. Note that limonene/β-phellandrene and myrtenol/myrtenal elute as single peaks, but their amounts are determined by the ratio of masses 68 and 79 (limonene), 77 and 93 (β-phellandrene), 108 and 152 (myrtenol), 107 and 150 (myrtenal). Volatile compounds were quantified by GC/FID using an Agilent 7890B and J&W DB-5, 0.25 mm x 60 m, 0.25 µm film thickness, fused silica capillary column. Operating conditions: 0.1 µL of sample (20% soln. for essential oils, 1% for reference compounds), splitless injection with purge flow to split vent 10 mL/min at 0.25 min, initial oven temperature at 40 °C with an initial hold time of 2 minutes, oven ramp rate of 3.0 °C per minute to 250 °C with a hold time of 3 minutes. For quantification, compounds were identified using retention indices coupled with retention time data of reference compounds.

The percent yield was calculated as the ratio of mass of processed plant material immediately before distillation to the mass of essential oil produced.

RESULTS AND DISCUSSION

Prominent compounds from steam distilled *J. osteosperma* whole tree essential oil are α-pinene (40.5%), sabinene (4.7%), ρ-cymene (2.7%), limonene (4.2%), camphor (6.7%), bornyl acetate (6.7%), cis-thujopsene (5.6%), and cedrol (2.9%) (Table 1). All volatile compounds present in the essential oils of *J. osteosperma* trunk, limb, and leaf, separately distilled, are also present in the essential oil distilled from the whole tree, albeit at different relative area percentages. Prominent compounds from steam distilled trunk essential oil include α-pinene (59.4%), δ-3-carene (4.4%), cis-thujopsene (11.0%), and cedrol (3.0%). Prominent compounds from steam distilled limb essential oil include α-pinene (85.3%) and cis-thujopsene (1.3%). Camphor (28.3%) and bornyl acetate (15.8%) are the prominent compounds detected in the leaf essential oil (Table 1).

In *J. osteosperma* trunk essential oil, cis-thujopsene is present at 11.0%. In contrast, cis-thujopsene in leaf essential oil samples is either not detected or in trace amounts. When comparing different portions of the tree, the relative amount of cis-thujopsene detected is most abundant in samples near the heartwood (Table 1). From trunk to limb to leaf, the relative amount of cis-thujopsene decreases from 11.0%, to 1.3%, to trace and the relative amount of cedrol decreases from 3.0% to 0.4% to undetected, respectively.

The whole tree, trunk, limbs, and leaves have the following essential oil yields (w/w) respectively: 0.3%, 0.1%, 0.1%, and 0.8%. Each portion of a single whole tree was separated and weighed in order to calculate the distribution of mass and essential oil yield of the trunk, limb, and leaf material (Table 2).

Leaf samples (n=10) distilled throughout the eight-month period showed stark variation for camphor (10.9% to 47.6%) and bornyl acetate (3.0% to 27.7%) (Figure 1). These results and the variability observed in samples throughout the state of Utah (Figure 2) agree with previous findings of *J. osteosperma* leaf essential oils (Adams, 2012).

CONCLUSIONS

The whole tree *J. osteosperma* essential oil profile is abundant in α-pinene, sabinene, ρ-cymene, limonene, camphor, bornyl acetate, cis-thujopsene, and cedrol. Trunk essential oil is prominent in α-pinene, δ-3-carene, cis-thujopsene, and cedrol. Limb essential oil is prominent in α-pinene and cis-thujopsene. The leaf material provides the greatest yield (w/w), follow by the whole tree. The trunk and limbs provide the lowest yields.

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Table 1. Aromatic profile of *J. osteosperma* essential oil from the whole tree, trunk, limbs, and leaves (n=1 for each sample type). Compounds detected in the whole tree but not in select portions of the tree are denoted as not detected (nd) and values less than 0.1% as traces (t). Unidentified compounds less than 0.5% are not included. KI is the Kovat's Index using a linear calculation on DB-5 column. Relative area percent as determined by GC/FID.

KI	Compound	Whole Tree	Trunk	Limb	Leaf
921	tricyclene	1.9	0.2	0.4	2.6
924	α-thujene	0.7	t	t	0.6
932	α-pinene	40.5	59.4	85.3	3.7
945	α-fenchene	0.1	0.6	0.3	t
946	camphene	1.5	0.3	0.4	2.5
953	thuja-2,4(10)-diene	0.5	0.4	0.5	t
969	sabinene	4.7	0.3	0.5	8.8
974	β-pinene	0.5	0.6	0.8	0.2
988	myrcene	1.3	1.0	1.0	2.1
1002	α-phellandrene	0.3	t	nd	0.1
1008	δ-3-carene	0.5	4.4	1.1	nd
1014	α-terpinene	0.8	t	t	0.9
1020	ρ-cymene	2.7	0.3	0.3	2.3
1024	limonene	4.2	0.5	0.9	10.6
1025	β-phellandrene	0.7	0.3	0.1	0.4
1044	trans-β-ocimene	0.3	0.2	0.3	0.2
1054	γ-terpinene	1.3	t	t	1.5
1065	cis-sabinene hydrate	0.1	nd	nd	0.3
1089	ρ-cymenene	0.8	0.5	0.2	0.7
1098	trans-sabinene hydrate	0.1	nd	nd	1.0
1122	α-campholenal	0.3	0.2	0.3	t
1135	trans-pinocarveol	0.6	0.5	0.6	0.4
1141	camphor	6.7	0.3	0.3	28.3
1145	camphene hydrate	0.2	nd	nd	1.7
1160	pinocarvone	0.1	0.2	0.2	nd
1165	borneol	1.6	t	t	3.9
1174	terpinen-4-ol	2.0	t	t	4.7
1186	α-terpineol	0.3	1.1	t	0.2
1194	myrtenol	0.2	0.2	0.1	t
1195	myrtenal	0.2	0.5	0.3	t
1204	verbenone	0.3	0.3	0.3	0.1
1215	trans-carveol	0.2	nd	0.1	0.5
1239	carvone	0.2	nd	t	0.5
1241	carvacrol, methyl ether	0.3	1.3	0.7	nd
1283	isobornyl acetate	0.4	nd	nd	0.7

KI	Compound	Whole Tree	Trunk	Limb	Leaf
1284	bornyl acetate	6.7	0.3	0.9	15.8
1410	α-cedrene	1.3	0.8	0.1	nd
1417	trans-caryophyllene	0.2	0.1	0.1	nd
1419	β-cedrene	0.2	0.5	t	nd
1429	cis-thujopsene	5.6	11.0	1.3	t
1452	α-humulene	0.1	nd	t	nd
1465	thujopsadiene	0.2	0.2	nd	nd
1498	pseudowiddrene	0.1	0.2	nd	nd
1504	cuparene	0.2	0.3	t	nd
1513	γ-cadinene	0.3	0.6	nd	nd
1522	δ-cadinene	0.4	0.2	nd	0.1
1548	elemol	0.8	t	0.1	1.9
1582	caryophyllene oxide	0.2	nd	0.1	nd
1589	allo-cedrol	0.1	0.2	nd	nd
1599	widdrol	0.5	1.7	0.1	nd
1600	cedrol	2.9	3.0	0.4	nd
1630	γ-eudesmol	0.3	0.7	0.2	0.2
1649	β-eudesmol	0.3	0.7	0.3	0.4
1652	α-eudesmol	0.1	0.4	0.2	t
1688	cedr-8-en-13-ol	0.2	0.4	nd	nd

Table 2. Distribution of mass and essential oil (EO) yield from a single *J. osteosperma* tree (the number was limited to one as per permit restrictions). Tree was cut 0.25 m above ground; all measurements and calculations are reflective of above ground portions.

	Whole tree	Trunk	Limb	Leaf
mass (kg)	209.5	77.9	68.1	63.5
mass (%)	100.0	37.2	32.5	30.3
mass distilled (g)	1141.3	1929.6	1741.3	1200.4
yield EO (g)	3.5	2.3	1.7	10.1
yield EO (%)	0.3	0.1	0.1	0.8

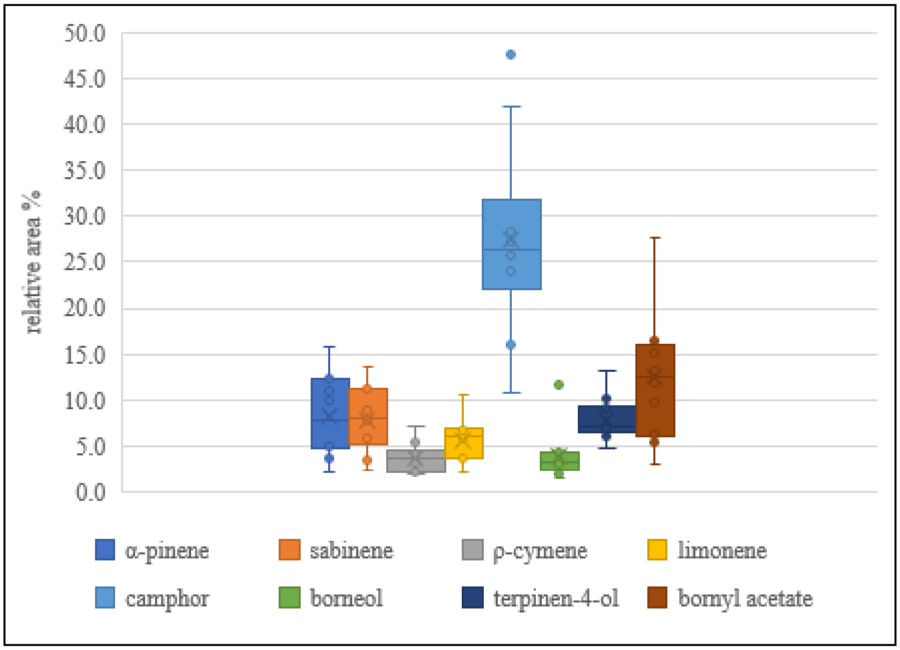

Figure 1. Average aromatic profile for *J. osteosperma* leaf essential oil (n=10) over an 8-month period. Compounds shown are abundant in the essential oil. Extreme outliers were present for camphor (mean of 27.4, outlier of 47.6) and borneol (mean of 4.0, outlier of 11.8). Relative area percent as determined by GC/FID.

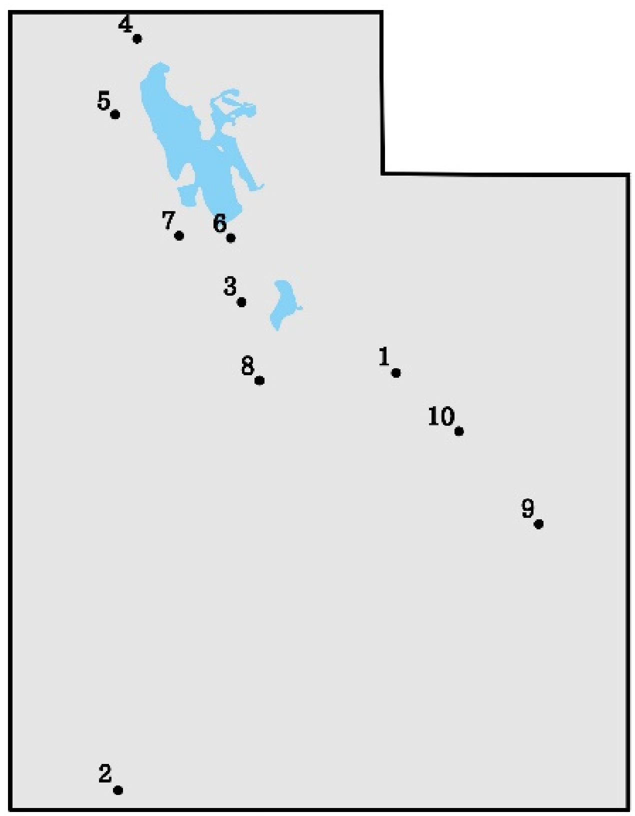

Figure 2. Map showing collection sites of *J. osteosperma* plant material. Samples were collected in sequence, 1-10. The following are sample collection dates and elevation: 1) 27 Mar 2018, 2140 m; 2) 8 May 2018, 1548 m; 3) 31 May 2018, 1667 m; 4) 30 Jul 2018, 1427 m; 5) 30 Jul 2018, 1509 m; 6) 30 Jul 2018, 1524 m; 7) 30 Jul 2018, 1448 m; 8) whole tree, 29 Aug 2018, 1744 m; 9) 5 Oct 2018, 1420 m; 10) 5 Oct 2018, 1631 m.