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ESSENTIAL OIL COMPOSITION OF *Persea duthiei*

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Persea duthiei King ex Hook. f. syn. *Machilus duthiei* King ex Hook. f. is a small or medium-sized evergreen tree widely distributed around Nainital, ascending to 2500 m. The fruit is a globular black drupe. The root stocks are acrid, bitter, pungent, heating, and astringent and are generally used in inflammation, asthma, pain, foul breath, bronchitis, vomiting, and in blood disease [1–3].

Various *Persea* species have been subjected to chemical investigations in the past. The GC and GC-MS analysis of the leaf oil of *P. americana* Mill. of Mexican origin revealed estragol (78.1%), α-cubebene (3.6%), methyl eugenol (3.4%), and β-caryophyllene (2.1%) as the major constituents, while its fruit oil was mainly composed of (*E*)-nerolidol along with lesser amount of β-caryophyllene, β-pinene, *trans*-β-bergaptene, and β-bisabolene [4, 5]. The leaf essential oil of *P. americana* Mill from Nigeria showed β-caryophyllene (43.9%) and valencene (16.0%) as the major constituents [6]. The GC and GC-MS analysis of leaf oils of *P. indica* showed β-caryophyllene (18.0%), germacrene D (15.4%), and (*E*)-avocadienofuran (16.0%) as the major constituents [7]. Methyl chavicol (78.0%) has been reported as the major constituent from the leaf oil of *P. grattissima* [8]. The flower oil of *P. bombyciana,* a host plant for the muga silk worm (*Antheraea assama*), was mainly dominated by caryophyllene oxide (19.4%), (*E*)-nerolidol (14.5%), 11-dodecenal (11.2%), and 11-dodecenoic acid (9.8%), while its fruit oil contained *trans*- and *cis*-linalool oxides (15.3%) [9]. The leaf oil of *P. bombyciana* was characterized by 2-dodecanal (26.5%), decanal (12.5%), 11-dodecenal (8.1%), dodecanoic acid (9.0%), and caryophyllene oxide (7.0%) along with other mono- and sesquiterpenoids [10]. Among reports of three Southern-North American *Persea* species examined by GC and GC-MS, the oil from *P. borbonia* was dominated by camphor (34.7%) and 1,8-cineole (17.7%), the oil from *P. humilis* was characterized by camphor (46.9%) and 1,8-cineole (12.7%), and the major constituents of *P. palustris* were 1,8-cineole (17.0%), *p*-cymene (14.8%), and camphor (10.6%) [11]. The leaf oil of *P. pododenia* of Mexican origin was shown to contain α-pinene (20.4%), δ-3-carene (15.9%), and limonene (12.1%) as the major constituents [12]. Diterpenes isolated from *P. indica* were shown to have potent antifeedant and insecticidal activity [13–16]. Biologically active cytotoxic lignans and neolignans have also been reported from the genus *Persea* [17–22]. Hussain et al. reported aporphine alkaloids from the root of *P. duthiei* [23], while there is no report on its essential oil composition.

The present analysis of leaf, fruit, and flower oils of *P. duthiei* resulted in the identification of 41 constituents representing 94.1%, 89.3%, and 90.4% of the total constituents of the leaf, fruit, and flower oils, respectively. The identified constituents of the oils are listed in Table 1 in order of their elution in an Rtx-5 column (30 m × 0.25 mm, 0.25 μm film thickness; 60–210°C, 3°C/min, He gas 1 mL/min). The major compounds (**1–6**) were isolated and identified by comparing their NMR data (^{1}H and ^{13}C NMR) with those reported in the literature. Thus, the analysis revealed that monoterpene hydrocarbons (36.4%) constituted the major proportion of the leaf oil of *P. duthiei*, while sesquiterpenoids constituted a greater percentage of fruit and flower oils (83.0% and 84.2%, respectively). The leaf oil consisted of monoterpene hydrocarbons (36.4%) and oxygenated sesquiterpenoids (35.7%) dominated by limonene (10.1%), α-pinene (10.0%), β-pinene (10.0%), *p*-cymene (3.5%), (*E*)-nerolidol (13.2%), *epi*-cubebol (5.8%), β-caryophyllene (5.8%), β-eudesmol (4.0%), and γ-muurolene (4.0%). The fruit and flower oils were mainly dominated by sesquiterpenoids (83.0% and 84.2%, respectively). The fruit oil was characterized by a high content of sesquiterpene alcohols (65.7%) with (*E*)-nerolidol (24.5%), β-eudesmol (10.9%), selin-11-en-4-α-ol (9.1%), and (*Z*)-nerolidol (7.7%) as major constituents. (*E*)-Nerolidol (15.2%) was also the major constituent of the flower oil besides *epi*-cubebol (11.5%), γ-muurolene (11.5%), and β-caryophyllene (7.9%).

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TABLE 1. Essential Oil Composition of *Persea duthiei* (Identification RRI, MS)

Compound	RRI	Oil			Compound	RRI	Oil		
		Leaf	Fruit	Flower			Leaf	Fruit	Flower
***α*-Pinene**	939	**10.0**	**0.2**	**1.5**	*β*-Gurjunene	1432	0.3	0.5	Tr.
Camphene	955	0.5	–	Tr.	*cis*-*β*-Farnesene	1145	0.1	0.2	Tr.
***β*-Pinene**	981	**10.0**	**0.8**	**1.2**	*α*-Humulene	1455	2.1	0.9	2.7
Myrcene	992	1.7	Tr.	0.2	***γ*-Muurolene**	1477	**4.0**	**3.2**	**11.5**
p-Cymene	1026	3.5	Tr.	Tr.	*β*-Selinene	1486	1.9	3.0	2.3
Limonene	1033	**10.1**	**0.6**	**0.7**	***epi*-Cubebol**	1492	**5.8**	**2.6**	**11.5**
1,8-Cineole	1035	1.8	0.2	0.4	*α*-Bulnesene	1505	0.1	3.7	0.9
Terpinolene	1086	0.6	0.2	0.4	Cubebol	1516	2.9	0.9	2.4
Linalool	1098	0.4	0.3	0.2	*cis*-Calamene	1524	1.1	0.3	1.3
cis-*p*-Mentha-2-en-1-ol	1121	Tr.	0.5	Tr.	**(*Z*)-Nerolidol (2)***	1534	**0.5**	**7.7**	**1.7**
trans-*p*-Mentha-2-en-1-ol	1142	0.1	Tr.	–	**(*E*)-Nerolidol (3)***	1564	**13.2**	**24.5**	**15.2**
Camphor	1143	0.1	–	–	Spathulenol	1578	0.7	Tr.	0.6
α-Terpineol	1190	0.2	0.3	0.1	Caryophyllene oxide	1580	0.4	0.6	0.5
Bornyl acetate (**1**)	1285	2.9	3.2	1.5	Guaiol**	1595	2.4	4.6	2.8
δ-Elemene	1340	0.1	0.1	0.2	1,10-*di*-*epi*-Cubenol	1615	0.7	1.0	0.7
α-Cubebene	1350	Tr.	1.4	Tr.	10-*epi*-*γ*-Eudesmol	1619	2.5	1.0	2.6
Longicyclene**	1374	0.1	–	0.1	***epi*-*α*-Cadinol (4)***	1640	**1.0**	**3.0**	**5.9**
α-Copaene	1378	0.2	Tr.	0.1	***β*-Eudesmol (5)***	1650	**4.0**	**10.9**	**5.9**
β-Patchoulene	1380	0.6	Tr.	0.3	**Selin-11-en-4*α*-ol (6)***	1655	**1.3**	**9.1**	**4.4**
β-Cubebene	1391	0.1	1.9	1.2	*α*-Bisabolol	1683	0.3	0.4	1.5
***β*-Caryophyllene**	1418	**5.8**	**1.5**	**7.9**	Total		94.1	89.3	90.4

RRI: Relative retention index calculated against *n*-alkane series on Rtx-5 column.
*Identification: RRI, GC-MS, NMR (^{1}H and ^{13}C).
Tr.: trace (<0.1%); **tentatively identified; compounds higher than 5% are highlighted in boldface.

The major essential oil constituents reported in *Persea* species, viz. (*E*)-avocadienofuran, methyl chavicol, 2-dodecanal, decanal, 11-dodecenal, dodecenoic acid, linalool oxides, and *δ*-3-carene, were not detected even as trace constituents in the oils from the leaves, flowers, and fruits of *P. duthiei* in the present investigations.

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