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Rhizome and Leaf Oil Composition of *Curcuma longa* from the Lower Himalayan Region of Northern India

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Abstract

The essential oils of *Curcuma longa* L. (Zingiberaceae) were isolated from its rhizomes and leaves by hydrodistillation. The oils were analyzed by high resolution GC and GC/MS. Fifty-two constituents were identified from rhizome oil representing 98.6% of the oil. The major constituents of the oil were α-turmerone (44.1%), β-turmerone (18.5%) and ar-turmerone (5.4%). From the leaf oil, 61 compounds were identified constituting 99.8% of the oil and main constituents were α-phellandrene (53.4%), terpinolene (11.5%) and 1,8-cineole (10.5%).

Key Word Index

Curcuma longa, Zingiberaceae, essential oil composition, α-turmerone, ar-turmerone, β-turmerone, α-phellandrene, terpinolene and 1,8-cineole.

Introduction

Curcuma longa L. (Zingiberaceae) rhizomes, commonly known as turmeric, have traditionally been used as a source of coloring matter for foods, cosmetics and textiles and as a medicinal ingredient of formulations of the Indian system of medicine for several common ailments (1). Turmeric is an underground storage organ that is rich in secondary metabolites, many of which have been identified and characterized, while newer ones are expected to be discovered. Turmeric powder, extracts and oleoresins are some of the widely used commercial products of *C. longa* plant. India is one of the largest producers of turmeric and its oleoresin (1-3). The oils and the diarylheptanoid curcumin, which are the major secondary metabolites for turmeric have been shown to be largely responsible for the pharmacological activities of turmeric powder, extracts and oleoresins. The main activities have been found to be anti-inflammatory, hepatoprotective, antimicrobial, wound healing, anticancer, antitumor and anti-viral (4). The oil of turmeric has been shown to possess the anti-inflammatory activity and to increase the bile flow. It was found to be effective against bronchial asthama in a clinical trial. Both the curcumin and the oil have been shown to possess wound healing properties and inhibitory activities against pathogenic fungi both in vitro and vivo (4). Discovery of antiviral properties in curcumin, particularly against HIV, is quite interesting (4).

The oil composition of *C. longa* from various parts of the world has been studied extensively (5-11). The leaf oil of *C. longa* from Vietnam contained mainly α-phellandrene (24.5%), 1,8-cineole (15.9%), p-cymene (13.2%) and β-pinene (8.9%) (12), while that of a Nigerian chemotype contained mainly α-phellandrene (47.7%) and terpinolene (28.9%) (13). The rhizome oils of Chinese cultivars had high contents of turmerone and ar-turmerone (14) along with other minor constituents (15,16). The effect of plant maturity on the composition of turmeric rhizome oil from Sri Lanka (17) revealed that turmerone content increased while 1,8-cineole and α-phellandrene declined with maturity. The chemical composition of rhizome oils of Malaysian *C. domestica* was determined (18), which contained significant amounts of α-turmerone (45.3%), linalool (14.9%) and β-turmerone (13.5%). The rhizome oil of *C. longa* from northern plains of India was reported to contain 59.7% of ar-turmerone (19) while the rhizome oil of another Indian chemotype was characterized by ar-turmerone (41.4%), turmerone (29.5%) and turmerol (20%) (20). Other turmeric oils from India contained zingiberene (25.0%) and ar-turmerone (25.0%) (21). Gopalam and Ratnambal (22) analyzed many South Indian cultivars and selection of *C. longa* and reported ar-turmerone, turmerone and limonene as major constituents. The oils of *C. longa* from northeastern region of India-Bhutan (23) have also been analyzed and major constituents in the rhizome oil were found to be ar-turmerol (16.7-25.7%), α-turmerone (30.1-32%) and

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β-turmerone (14.7-18.4%) as major constituents. Similarly, the leaf oil of Bhutanese origin had α-phellandrene (18.2%), 1,8-cineole (14.6%), p-cymene (13.3%) and terpinolene (11.6%) as the major constituents while the leaf oil from North Indian plains contained p-cymene (25.4%), 1,8-cineole (18%), *cis*-sabinol (7.4%) and β-pinene (6.3%) as major constituents (24).

Moreover, from the plains of northern India (25), various accessions of *C. longa* were analyzed for their curcumene and major oil contents. To the best of our knowledge no detailed GC/MS analysis of northern Indian rhizome and leaf oils of *C. longa* has been carried out. This promoted us to carry out the detailed GC/MS analysis of *C. longa* from lower Himalayan region.

Experimental

Plant material: Fresh rhizomes and leaves from the plants grown on pilot scale at CIMAP Field Station, Pantnagar, Uttranchal, India were collected in the month of September 2000. A voucher specimen of the plant material has been deposited in the Herbarium division of CIMAP, Lucknow.

Oil isolation: Fresh rhizomes (500 g) and leaves (350 g) were hydrodistilled in a Clevenger-type apparatus for 4 h, each afforded 0.8% and 0.65% of oil, respectively. The oils thus obtained were dried over anhydrous sodium sulfate and kept in refrigerator at 4°-5°C prior to analysis.

GC analysis: GC analyses of the oils were performed on Perkin Elmer 8500 gas chromatograph equipped with FID using BP-1 (methyl polysiloxane) (25 m x 0.32 mm). Nitrogen was used as carrier gas at a flow rate of 1.0 mL/min. and 8 psi inlet pressure; split 1:80; temp. program, 60°-220°C at 5°C/min, then held isothermal at 220°C for 5 min, then heated at 3°C/min to 245°C and held isothermal at 245°C for 5 min; injector temperature, 250°C; detector temperature, 300°C. Quantitative data were obtained from area percentages without the use of an internal standard or correction factors.

GC/MS analysis: GC/MS data were obtained on Perkin Elmer Turbo Mass spectrometer instrument using a PE-WAX column (60 m x 0.32 mm, film thickness 0.25 μm). Temperature programming: 5 min at 70°C, then rising at 2°C/min to 120°C and then 3°C/min from 120°-240°C. Carrier gas was helium.

Identification of compounds: Compounds were identified by comparing the retention indices of the peaks on a BP-1 column with literature values (18,23,26-30), computer matching against the library spectra built up using pure substances and components of known essential oils and finally confirmed by comparison of mass spectra of peaks and retention indices with published data (26-30). The relative amounts of individual components are based on peak areas obtained without FID response factor correction. The retention indices were obtained from gas chromatograms by logarithmic interpolation between bracketing n-alkanes. The homologous series of n-alkanes (C8-C22; Poly Science, Niles, USA) were used as standards.

Results and Discussion

The oils were obtained by conventional hydrodistillation of the rhizomes and leaves of *C. longa* in a Clevenger-type apparatus. Each gave an oil in 0.8% and 0.65% yield, respectively, on a fresh weight basis. GC and GC/MS analysis resulted in the identification of 52 and 61 constituents, respectively, from the rhizome and leaf oils.

The relative concentrations of the volatile components identified are presented in Table I, according to their elution order on BP-1 column. The main components of rhizome oil were α-turmerone (44.1%), β-turmerone (18.5%) and ar-turmerone (5.4%). While α-turmerone and β-turmerone were absent and ar-turmerone was present as a minor constituent in the leaf oil.

On comparing our results of the rhizome oil with those reported earlier from Lucknow, India (19) showed contrasting results with respect to the percentage content of the major constituents such as ar-turmerone (5.4% and 59.7%) and α-turmerone (44.1% and 3.6%). On the other hand, the oil composition of our rhizome oil matched to a great extent with that of the rhizome oil from Bhutan (23) with respect to the major constituents α-turmerone (44.1% and 30.1%), β-turmerone (18.5% and 14.7%) and minor constituents α-atlantone (1.1 and 1.2%). Apart from the above similarities our oil did show significant variations with Bhutanese oil (23) in the percentage content of some of the major and minor constituents such as α-phellandrene (9.4% and 1.7%), ar-turmerone (5.4% and 16.7%), zingiberene (2.3% and 4.2%), 1,8-cineole (2.1% and 7.6%), β-sesquiphellandrene (1.8% and 3.6%), terpinolene (1.2% and 0.7%) and p-cymene (1.2% and 0.5%).

It is interesting to note that when we compared our results with the average percentage of the major constituents of 27 rhizome accessions earlier collected from the same place (25) as ours and were mainly analyzed for turmerone and curcumene contents, we observed significant variations in α-turmerone (44.1% and 11.9%), β-turmerone (18.5% and 8.3%), ar-turmerone (5.4% and 25.4%), ar-curcumene (0.5% and 1.9%) and β-curcumene (0.4% and 2.0%).

On the other hand, comparison of our leaf oil composition with those reported from Kerala (South India) (26); Vietnam (22), Bhutan (23) and Nigeria (13) showed that our oil matched to a great extent with South Indian and Nigerian oils in the percentage composition of its major constituents α-phellandrene (53.4%, 57% and 48%) and terpinolene (11.5%, 12% and 29%). But it is very interesting to note that comparison of our results with very recently reported results of Garg et al. (24) on the leaf oil composition from the same place showed different results. α-Phellandrene and terpinolene, which have been reported as major constituents in our oil as well as in almost all the leaf oils of the world (12,13,23,26) were either absent or present in trace amounts in the oil reported by Garg et al. (24). This confirms that the variations in the cultivar reported by Garg et al. is not due to geographic divergence and ecological conditions but that is due to different chemotype than ours.

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Table I. Percentage composition of the rhizome and leaf oils of *Curcuma longa* L.

Compound	RI	Rhizome oil %	Leaf oil %	Compound	RI	Rhizome oil %	Leaf oil %
octane	801	t	-	isobornyl acetate	1270	-	t
α-thujene	928	t	0.1	geranyl formate	1279	-	0.1
α-pinene	935	0.4	2.3	sabinyl acetate*	1299	0.2	-
camphene	949	t	0.1	undecanol	1303	-	1.0
sabinene	971	t	0.3	geranyl acetate	1365	-	t
β-pinene	975	0.1	1.8	β-patchoulene	1378	-	t
myrcene	982	-	0.1	β-elemene	1384	-	0.3
2-octanol	986	0.4	3.0	tetradecane	1391	0.1	-
(Z)-3-hexenyl acetate	994	-	0.1	β-caryophyllene	1405	-	0.2
α-phellandrene	1003	9.4	53.4	γ-elemene	1428	0.2	0.1
δ -3-carene	1007	0.2	1.0	α-bergamotene*	1439	-	t
α-terpinene	1012	0.1	0.9	β-farnesene*	1451	0.3	0.2
p-cymene	1016	1.2	4.8	germacrene D	1461	-	t
limonene	1025	0.2	2.0	ar-curcumene	1477	0.5	-
1,8-cineole	1025	1.9	8.5	zingiberene	1492	2.3	0.1
(Z)-β-ocimene	1032	-	0.1	α-selinene	1498	0.1	0.2
(E)-β-ocimene	1044	t	0.4	β-curcumene	1506	0.4	-
γ-terpinene	1055	0.4	2.2	β-serquiphellandrene	1521	1.8	0.1
cis-linalool oxide (Furanoid)	1062	-	t	geranyl butyrate	1529	t	-
terpinolene	1084	1.2	11.5	(E)-nerolidol	1550	0.2	-
linalool	1092	0.1	0.8	ar-turmerol	1555	0.1	0.1
trans-p-menth-2-en-1-ol	1116	t	0.1	caryophyllene oxide	1571	0.4	t
p-methyl acetophenone	1129	-	t	epi-curzerenone	1585	0.3	-
camphor	1135	0.1	0.2	viridiflorol	1589	1.6	0.2
p-cymen-8-ol	1159	t	0.2	*trans*-sesquisabinene hydrate	1599	0.2	t
terpinen-4-ol	1165	-	t	humulene epoxide II	1608	0.6	0.1
myrtenal	1170	0.1	t	10-epi-γ-eudesmol	1613	0.2	-
α-terpineol	1172	-	0.1	T-cadinol	1625	1.7	0.1
myrtenol	1177	-	t	ar-turmerone	1650	5.4	0.6
cis-sabinol	1183	0.3	0.4	α-turmerone	1661	44.1	-
2-decanol	1191	-	0.3	germacrone	1682	0.4	0.3
cis-carvotanacetol	1198	-	0.1	β-turmerone	1690	18.5	-
cis-carveol	1207	-	0.1	geranyl hexanoate	1731	0.6	-
neral	1226	0.2	0.9	(E)-α-atlantone	1745	1.1	0.1
perilla ketone	1237	-	t	furanodienone	1752	0.2	-
linalyl acetate	1246	-	t	heptyl salicylate	1798	0.7	0.1
geranial	1253	-	0.1	cinnamyl cinnamate	2044	0.1	-

compounds are listed in order of elution on BP-1 column; t = traces; *correct isomer not identified

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