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Chemical Analysis of Essential Oils from Turmeric (*Curcuma longa*) Rhizome Through GC-MS

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The volatile oil of turmeric (*Curcuma longa* L., zingiberaceae) was isolated from its rhizomes. Gas chromatography-mass spectrometry (GC-MS) was applied to the methanolic extract of *C. longa*. The chromatographic analysis of oil showed 16 constituents of which, 6 compounds contributing 70.0 % of the total oil constituents could be identified. The compounds were identified on the basis of their fragmentation pattern and matching with the data library. The most abundant components were aromatic turmerone (25.3 %), α-tumerone (18.3 %) and curlone (12.5 %). Other constituents are caryophyllene (2.26 %) and eucalyptol (1.60 %). The component present in lowest amount is α-phellandrene (0.42 %).

Key Words: *Curcuma longa*, Turmerone, Curlone, Zingiberaceae, α-Tumerone.

INTRODUCTION

Zingiberaceae is among the plant families which are widely distributed throughout the tropics, particularly in Southeast Asia. There are 200 species of this family belonging to 20 genera. Turmeric has been used not only as a spice but as a natural colorant, to flavor the food stuff and also as an herbal medicine for many centuries. It is also an important medicinal plant whose fresh rhizomes and dried powder are popular remedies of blood disorders, cold, cough, jaundice and various skin diseases.Turmeric, *Curcuma longa* L. rhizomes, has been widely used for centuries in indigenous medicine for the treatment of a variety of inflammatory conditions and other diseases[1]. The wild turmeric is called *Curcuma aromatica* and the domestic species is called *C. longa*[2]. Its powder has long been used as a spice, coloring agent, cosmetic and medicinal agent in Asian and Eastern cultures[3]. It is very popular in Asian medicine for the treatment of coryza, hepatic disorders and rheumatism[4]. It is also used for hypercholesterolemia, arthritis, indigestion and liver problem since long[5]. Research indicates that turmeric and its active components (volatile oil and curcuminoids) have unique antioxidant, antitumorigenic, anticarcinogenic, antiinflammatory, antimutagenic, antiarthritic and antimicrobial properties as reviewed elsewhere[6,7].

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Essential oils are volatile and fragrant substance of plants. They are obtained from plants through steam distillation or other processes[8]. They may be present in particular secretory parts. Generally these oils contain volatile substances which are terpenes and their oxygenated derivatives usually known as camphors[9,10]. Chemical constituents of turmeric rhizomes include volatiles and non-volatiles. The chemical constituents of volatile oil were identified using GC and GC-MS and main components are ar-tumerone, zingiberene, turmerone and curlone. The non-volatile compounds are colouring agents and rich source of phenolics[11]. The aroma of the turmeric is contributed by its steam volatile essential oils while the phenolic compounds, curcumin and its analogues account for its bright yellow colour[12].

Aromatic tumerone (20-30 %) was reported to be the major compound present in turmeric volatile oil[13], which is a mosquito repellent[14] and may be an effective drug for the treatment of respiratory disease[15] and dermatophytosis[16]. Synthetic tumerone appears to act as anticarcinogenic[17]. Antivenom activity of tumerone isolated from turmeric has also been reported[18]. Recently, turmeric oil was found to be both as antifungal[19] and antibacterial[20] agents. Defence responces in plants against insects are generally triggered by volatiles[21-23].

EXPERIMENTAL

The rhizomes of *Curcuma longa* were collected from Ayub Agriculture Research Centre, Faisalabad.

Extraction of essential oils: The cut pieces of rhizome were subjected to hydro-distillation.

Steam distillation: Known weight of rhizomes were taken in reaction vessel and attached to steam generator. A water cool condenser was also attached with reaction vessel. Steam generator produced the steam which passed through the sample condensed and collected with essential oils. The oil was dried over anhydrous sodium sulphate and stored at 4 ºC till GC-MS analysis was carried out. The yield of the oil is calculated on the basis of fresh weight of sample.

GC-MS analysis: GC-MS of Varian, Saturn model 2000, equipped with ion trap detector (ITD) was used for the identification of different components of essential oil of *Curcuma longa*. Sample was injected on a DB-5MS (30 m × 0.25 mm id, 0.25 µ film thickness) column. Helium was used as a carrier gas with a flow rate of 7.0-9.5 psi and split ratio 1:5. The column temperature was maintained at 75 °C for 5 min with a 2.5 °C rise/min to 250 °C.

Various components were identified by their retention time and peak enhancement with standard samples in gas chromatographic mode and MS library search from the derived mass fragmentation pattern of various components of the essential oil.

RESULTS AND DISCUSSION

The essential oil was extracted from rhizomes of *Curcuma longa* by hydro-distillation. The yield of oil was 0.673 %. GC-MS analysis of turmeric revealed the presence of 16 components. Out of which, six have been identified from their fragmentation pattern by mass spectroscopy (Table-1). The oil was found to be the mixture of monoterpenes and sesquiterpenes. As reported by He *et al.*[24], sesquiterpenoids are the major constituents of turmeric oil and ar-turmerone (25.3 %) was identified as a major component followed by α-tumerone (18.3 %) and curlone (12.5 %). These tumerones have similar chemical structures, physical properties and molecular weights, even though they have different tastes[25]. For instance, it was reported that ar-turmerone is the best local treatment for edema, necrosis and local hemorrhage after Bothrops alternatus envenomation[26]. Moreover, ar-turmerone has been shown to display antiplatelet activity and is a more potent platelet inhibitor against platelet aggregation induced by collagen than aspirin[27]. In addition ar-turmerone is assumed to improve insulin resistance and ameliorate type 2 diabetes mellitus through the same biological mechanism as thiazolidinedione derivatives[28]. Furthermore, the insect repellent and anti-feeding properties of *Curcuma* have been attributed to turmerone[29,30] and curcuminoids[31].

TABLE-1
GC-MS ANALYSIS OF ESSENTIAL OIL OF KASUR TURMERIC VARIETY

Name of compounds	R:T	m.f.	m.w.	Percentage (%)	m/e Value
α-Phellandrene	7.29	$C_{10}H_{16}$	136	0.42	M^+ 51 (5 %), 65 (7 %), 77 (37 %), 93 (100 %), 105 (4 %), 115 (2 %), 121 (3 %), 136 (29 %)
Eucalyptol	7.75	$C_{10}H_{18}O$	154	1.62	M^+ 51 (6 %), 55 (48 %), 59 (18 %), 67 (35 %), 71 (66 %), 77 (12 %), 81 (90 %), 84 (68 %), 93 (69 %), 96 (39 %), 108 (100 %), 111 (86 %), 125 (16 %), 136 (13 %), 139 (81 %), 154 (92 %)
Caryophyllene	13.92	$C_{15}H_{24}$	204	2.26	M^+ 51 (7 %), 55 (26 %), 69 (59 %), 79 (70 %), 83 (4 %), 93 (94 %), 93 (94 %), 105 (62 %), 109 (17 %), 120 (45 %), 133 (100 %), 147 (37 %), 161 (43 %), 175 (13 %), 189 (27 %), 204 (9 %)
Ar-tumerone	20.01	$C_{15}H_{20}O$	216	25.33	M^+ 51 (3 %), 55 (22 %), 65 (6 %), 77 (16 %), 83 (100 %), 91 (27 %), 98 (4 %), 105 (53 %), 111 (14 %), 115 (8 %), 119 (67 %), 132 (15 %), 201 (24 %), 216 (32 %)
Tumerone	20.10	$C_{15}H_{22}O$	218	18.35	M^+ 55 (23 %), 77 (26 %), 83 (88 %), 91 (36 %), 99 (5 %), 105 (100 %), 111 (31 %), 120 (55 %), 126 (6 %), 200 (8 %)
Curlone	20.70	$C_{15}H_{22}O$	218	12.50	M^+ 55 (13 %), 77 (9 %), 83 (29 %), 91 (17 %), 105 (19 %), 120 (100 %), 218 (4 %)

Eucaluptol (1.6 %), the monoterpene cyclic ether, was identified in *Curcuma* extract. It is also known by a variety of synonyms: 1,8-cineol, limonene and cajeputol. This component might contribute to the characteristic fresh and camphoraceous fragrance and pungent taste of turmeric. As a result of this, *Curcuma* extracts could also be incorporated in pharmaceutical formulations for use as an external applicant, nasal spray, cosmetic, food flavouring and analgesic, as well as disinfectants[32].

α-Phellandrene (0.42 %) was found in very low amounts. Caryophyllene (2.26 %) was also identified as natural bicyclic sesquiterpene. There is considerable quantitative variation in the percentages of main components depending upon the cultivars from which the oil is produced.

The present data represented essential oil composition of Pakistan turmeric which had not been reported before while the oil composition of *C. longa* from its various parts of the world has been studied extensively[33]. The essential oil from turmeric rhizomes from Calicut, India[34] having components of ar-tumerone (31.1 %), tumerone (10.0 %), curlone (10.6 %) and ar-curcumerene (6.3 %). The chemical analysis of rhizome oils of Malaysian *C. domestica* was determined[35] which contained significant amounts of α-tumerone (45.3 %), β-tumerone (13.5 %), linalool (14.9 %). The major oil constituents of *C. longa* from northeastern region of India, Bhutan[36] were α-tumerone (45.3 %), β-tumerone (13.5 %), linalool (14.9 %).

The rhizome oil of *C. longa* from northern plains of India was reported to contain 59.7 % of ar-turmerone[37] while the rhizome oil of another Indian chemotype[38] was characterized by ar-tumerone (41.4 %), tumerone (29.5 %) and turmerol (20 %). Other turmeric oils from India[39] contained zingiberene (25.0 %) and ar-turmerone (25.0 %). The major constituents of the rhizome oil[40] were α-turmerone (44.1 %), β-tumerone (18.5 %) and ar-turmerone (5.4 %).

Essential oils[41] from rhizome of *C. longa* contained a lower concentration of ar-turmerone (4.0-12.8 %). It was reported that GC-MS of hexane extract of turmeric rhizome[42] gave very different percentage of components *e.g.*, ar-turmerone (2.6-70.3 %), α-turmerone (trace-46.2 %) and zingiberene (trace-36.8 %).

The rhizome oil of *C. longa* of Chinese origin was analyzed by GC-MS[43]. The oil was reported to contain 17 chemical constituents of which turmerone (24 %), ar-turmerone (18 %) and germacrone (11 %) are the major compounds.

The best processing conditions to maximize the yields of essential oil and pigments, as well as their contents of ar-turmerone, (α and β)-turmerone and the curcuminoids, respectively have been reported. Autoclave pressure and distillation time were the variables studied for the steam distillation process and the highest yield of essential oil was 0.46 wt %[44]. The oil produced from 5-10 month old *C. longa* rhizomes that were grown in Bhutan was analyzed using GC and GC-MS[45]. The major compounds were found to be ar-turmerone (16.7-25.7 %), α-turmerone (30.1-32.0 %) and β-turmerone (14.7-18.4 %).

The metabolic profile of polar (methanol) and non-polar (hexane) extracts of *Curcuma* domestica from Korea was established[46]. GC-MS of hexane fraction revealed a high proportion of ar-turmerone (19.5 %), α-turmerone (20.1 %) and α-turmerone (17.6 %).

The spectrum of α-turmerone[47] shows the molecular ion at m/z 216, ions for loss of methyl (m/z 201), α-cleavage to the aromatic ring (m/z 119) and α-cleavage to the carbonyl (m/z 83). There are also two odd electron ions at m/z 132 and m/z 98 that result from McLafferty rearrangements.

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