Available online on www.ijppr.com
International Journal of Pharmacognosy and Phytochemical Research 2015; 7(1); 38-44

ISSN: 0975-4873

Research Article

Chemical Composition, Antimicrobial and Antioxidant Activities of Essential Oils from Leaves and Fruits of *Commiphora caudata* Engl.

Prasanna Anjaneya Reddy L[1,5*], Narasimha Reddy B[1], Bhakshu M D L[2], Venkata Ratnam K[3], Veeranjaneya Reddy L[4]

[1]*Deparment of Botany, Osmania University, Hyderabad, Telangana - 500 007, India*
[2]*Department of Botany, Govt. College for Men, Kadapa, Andhra Pradesh - 516 001, India*
[3]*Deparment of Plant Sciences, University of Hyderabad, Hyderabad, Telangana - 500 046, India*
[4]*Deparment of Microbiology, Yogi Vemana University, Kadapa, Andhra Pradesh - 516 003, India*
[5]*Lipidomics Centre, CSIR-Central Food Technological Research Institute, Mysore, Karnataka 570020, India*

Available Online: 1st February, 2015

ABSTRACT

The leaf and fruit essential oils were obtained from *Commiphora caudata* Engl. were examined by gas chromatography (GC) and gas chromatography-mass spectroscopy. Fifteen compounds from leaf oil and thirty compounds from fruit oil were identified which represents 100% and 99.97% respectively. The major components of leaf oil are β-pinene (33.70%), cychlofenchene (17.84%) and α-terpineol (10.40%) whereas the fruit oil contain verbenone (8.18%), 3-carene (9.90%), cychlofenchene (16.97%) and dihydrocarveol (19.58%) as the major components. The essential oil exhibited broad spectrum of antimicrobial activity which is concentration dependent and 10 µL of the leaf oil shown the inhibition zones ranging from 8.5-19.5 mm and 9.0 -26.2 mm for fruit oils. The MIC were ranged from 4.2-10.0 µL/mL for leaf and 3.3-10.0 µL/mL for fruit oils. Fruit oil exhibited strong inhibition activity (26.2 mm zone of inhibition) compared to standard anti-fungal drug Amphotericin B (24.0 mm) against *Candida rugosa*. The essential oils exhibited significant DPPH scavenging activity in concentration dependent manner (5-20 µL). Leaf and fruit oils displayed 50% scavenging capacity (IC_{50}) with 20 µL and 15 µL respectively. Total anti-oxidants of leaf and fruit oils calculated in terms of ascorbic acid equivalents were: 18.1 ± 2.7 and 184.3 ± 5.6 g/kg, respectively. This is the first report on the chemical profiles, anti-microbial and anti-oxidant activities of *C. caudata* leaf and fruit essential oils.

Key words: *Commiphora caudata*, essential oils, Chemical composition, anti-microbial activity, anti-oxidant activity.

INTRODUCTION

Commiphora caudata Engl. (Syn. *Protium caudatum* Wight & Arn.) commonly known as hill-mango is a moderate-sized (18 m tall), evergreen, aromatic tree (leaves 3-7 foliolate, leaflets elliptic-ovate, 3-10 × 1.5-6 cm, glabrescent, acute, base unequal. Flowering and fruiting occurs from March-October, red flowers born in axillary cymes with solitary seeds) belongs to the family Burseraceae and grows in dry or semi-evergreen forests of South India[1]. Forest dwelling local communities utilize the fruits and leaves in food preparations for mango-like flavour. Leaves are used for stomach ailments [2], fruits used in pickles preparation and also for healing wounds [3], gum resin for treating stomach troubles [4]. The extracts obtained from the leaves has been studied for anti-bacterial [4], pharmacological [5], anti-inflammatory, analgesic, anti-lipid peroxidation [6, 7] and anti-oxidant [8] properties. Bark and gum extracts studied for anti-ulcer effect in rat models [9].

From ancient times, the plants have been used as raw material for cosmetics, pharmaceuticals, botanical pesticides, disinfectants, insect repellents, herbal teas, herbal drinks, etc. Chemical constituents of plant origin have long been known to possess several biological activities [10]. It is estimated that about 50,000-70,000 plant species are used in traditional and modern medicine throughout the World. These species make a significant contribution to healthcare and along with species used for their aromatic properties, in herbal products, pharmaceuticals and fragrances [11]. The essential oils are effective against microorganisms, and have been recognized as natural antioxidants. Number of medicinal, aromatic, plants species have ingredients with antimicrobial and antioxidant properties[12-16], with reference to the plants, rosemary[17], sage[18], and oregano[19], which resulted in the boost of natural antioxidant formulations in food, cosmetic and pharmaceutical applications.

The review of literature indicates, no study was reported on phutochemical and pharmacological properties of *C. caudata* essential oils. In view of the above advantages, the present investigation was carried out to study the chemical composition, antimicrobial and antioxidant activities of *C. caudata* essential oils isolated from leaves

**Author for Correspondence*

and fruits using *in vitro* assays. However, to the best of authors' knowledge, this is the first report on the chemical profiles and biological activities of essential oils of *C. caudata.*

MATERIALS AND METHODS

Plant Material

Commiphora caudata leaves and fruits were collected from the forests of Seshachalam Hills, part of Eastern Ghats, Andhra Pradesh, India. The voucher specimen was identified by Dr. Prasanna Kumar, Botanical Survey of India (BSI), Deccan Circle, Hyderabad, India, where a voucher specimen (BSID 000826) was deposited.

Isolation of Essential Oil

The fresh leaves and fruits (500g each) were separately subjected to hydro-distillation for 4 -5 h in Clevenger-type glass apparatus [20]. The essential oil samples which gives mango-like aroma were dried over anhydrous sodium sulphate and stored at 4 ºC until used for chemical analysis and biological activities.

GC Analysis of Essential Oil

Gas chromatographic analysis of the essential oil samples were carried out employing Varian CP-3800 GC (Varian Inc., Netherlands) having Galaxie chromatography data system and fitted with flame ionization detector (FID), electronic detector and dimethylpolysiloxane (100%) column CP Sil-5 CB: 50 m length × 0.25 mm internal diameter × 0.4 µm film thickness. Nitrogen was the carrier gas with 16 psi inlet pressure and 0.5 mL/min flow rate. Samples (0.2 µL) were injected in split mode with a ratio of 1:100. The column temperature was programmed from 60-250 ºC at 5ºC/min ramp rate. Injector and detector temperatures were maintained at 250 and 300 ºC respectively.

Analysis and Identification of Essential Oil Constituents

The chemical profile has been carried out using GC and GC-MS analysis.GC-MS analyses were performed at 70 eV ionization energy with a mass range of 40-500 on Shimadzu 2010 GC-MS {Shimadzu Analytical (India) Pvt. Ltd.} equipped with QP 2010 and DB-5 (5% phenyl and 95% dimethylpolysiloxane) column (Agilent Technologies Inc., USA) of 30 m length × 0.25 mm internal diameter × 0.25 µm film thickness. Helium used as carrier gas with a flow rate of 1.67 mL/min. The injection port was maintained at 250 ºC and the detector at 220 ºC. Oven temperature was programmed from 100-240 ºC at 5 ºC/min rising rate. Samples (0.2 µL) were injected neat with a split ratio of 1:30.

Essential oil components were identified by comparison of the retention indices of the GC peaks with those obtained using saturated *n*-alkanes (C_8-C_{23})[21], and confirmation was done with those reported in the literatures[22, 23] as well as NIST library. Peak area percentages were calculated from GC-FID response without employing correction factors.

Determination of Anti-microbial Activity

Microbial Strains

The *in vitro* anti-microbial activity of the essential oils was studied by disc diffusion[24] method recommended by Clinical Laboratory Standards Institute (CLSI, formerly National Committee for Clinical Laboratory Standards, 2008) [25]. Anti-microbial activity was carried out against 2 gram-positive bacteria namely *Bacillus subtilis* (MTCC 1429) and *Staphylococcus aureus* (MTCC 737); 2 gram-negative bacteria *Escherichia coli* (MTCC 1687) and *Pseudomonas aeruginosa* (MTCC 1688); 2 fungi namely *Candida albicans* (MTCC 227) and *Candida rugosa* (NCIM 3462). The bacterial stains and fungal species used for the investigation were procured from CSIR-Institute of Microbial Technology {Microbial Type

Table 1.Chemical profiles of *Commiphora caudata* leaf and fruit essential oils

S. No.	Compounds	Retention Index	Area %	
			Leaf	Fruit
1	Cychlofenchene	729	17.84	16.97
2	β-Pinene	943	33.70	2.58
3	3-Carene	948	-	9.90
4	*tert*-Butylbenzene	1007	-	1.11
5	D-Limonene	1018	-	0.89
6	*p*-Mentha-1,3,8-triene	1029	-	1.11
7	*m*-Cymene	1042	-	2.62
8	1,8-Cineole	1059	0.94	2.05
9	Thujen-2-one	1073	2.02	1.91
10	β-Linalool	1082	1.48	1.23
11	Nonanal	1104	-	0.91
12	2-pinene-4-one	1119	1.37	-
13	Verbenone	1119	-	8.18
14	Phenylacetone	1128	-	3.75
15	2(10)-Pinene-3-ol	1131	-	2.51
16	Verbenol	1136	5.40	1.73
17	Myrtenal	1136	3.45	0.87
18	4-Terpineol	1137	3.79	-
19	*cis-p*-Mentha-2,8-dienol	1140	-	0.90
20	Melilotal	1142	-	1.12
21	α-Terpineol	1143	10.40	-
22	α-Campholenal	1155	-	1.00
23	1-Nonanol	1159	-	1.20
24	Myrtenol	1191	3.73	0.86
25	Dihydrocarveol	1196	-	19.58
26	*p*-Cymene-8-ol	1197	-	6.05
27	Carveol	1206	-	1.37
28	1-Decanol	1258	-	1.83
29	Linalool acetate	1272	2.61	1.15
30	Capric acid	1372	-	2.41
31	Caryophyllene	1494	1.66	-
32	Caryophyllene oxide	1507	9.82	0.96
33	Ledol	1530	1.79	-
Oxygenated hydrocarbons			-	4.24
Monoterpene hydrocarbons			51.54	32.56
Oxygenated monoterpens			35.19	50.32
Sesquiterpen hydrocarbons			1.66	-
Oxygenated sesquiterpenes			11.61	0.96
Aromatic compounds			-	8.67

Table 2. Antimicrobial activity of *Commiphora caudata* leaf and fruit essential oils

Organisms	Inhibition zone (mm)						
	Pure oil (10 µL)		1:1 dilution (5 µL)		1:5 dilution (2 µL)		Standards▲
	Leaf	Fruit	Leaf	Fruit	Leaf	Fruit	
Gram-positive bacteria							
B. subtilis	8.5 ±1.5	9.0±1.0	-	-	-	-	19.0±1.5
S. aureus	14.0±1.0	14.0±.5	12.0±1.0	12.0±1.0	10.0±0.5	10.0±1	21.0±2.0
Gram-negative bacteria							
E. coli	12.0±1.0	16.5±1.5	9.0±1.5	6.0±1.0	6.0±1.0	-	23.0±1.5
P. aeruginosa	10.8±1.0	10.2±1.2	7. 7±0.5	7.8±0.6	-	9.0±1.0	25.0±2.0
Fungi							
C. rugosa	19.5±2.0	26.2±	11.0±1.2	15.3±1.5	10.0±1.5	10. 7±1.2	24.0±1.0
C. albicans	-	9.8±1.5	9.0±1.0	10.0±1.0	-	-	19.0±1.5
LSD at 5%							
Concentrations	0.29	0.29		Organisms	0.41	0.42	
Interactions	0.72	0.73		Standard	0.68	0.68	

▲Penicillin, Streptomycin, Amphotericin B, LSD=Least square difference.

Table 3. Minimum inhibitory concentrations of *C. caudata* leaf and fruit essential oils against 4 bacteria and 2 fungi

Treatments	Minimum inhibitory concentration (µL/mL)						LSD at 5%
	B. subtilis	*S. aureus*	*E. coli*	*P. aeruginosa*	*C. rugosa*	*C. albicans*	
Leaf	10.0± 1.0	4.2±1.2	5.0±0.5	10.0±0.5	5.0±1.0	10.0±1.5	1.6
Fruit	10.0±1.5	5.0±1.0	3.3±	3.3±0.5	3.3±0.5	10.0±1.2	2.8
Penicillin	6.5±0.5	1.6±0.5	-	-	-	-	2.1
Streptomycin	-	-	1.6±0.25	1.6±0.25	-	-	1.2
Amphotericin B	-	-	-	-	1.6±1.0	1.6±1.5	1.2

LSD, Least square difference

Culture Collection Centre (MTCC)}, Chandigarh and CSIR-National Chemical Laboratory {National Collection of Industrial Microbiology (NCIM)}, Pune, India. Bacterial cultures were maintained on nutrient agar (NA) and fungal cultures on potato dextrose agar (PDA) media.

Anti-microbial Screening

Essential oil of leaf and fruit in three different concentrations (i.e., undiluted, 1:1 and 1:5 diluted) were used. Sterile Whatmann number 1 filter paper discs of 6 mm diameter impregnated with the essential oils were placed on nutrient/dextrose agar plates were pre-seeded with bacterial/fungal strains. Negative controls were maintained with DMSO and positive controls with standard antibiotics namely, Penicillin, Streptomycin for bacteria and Amphotericin B for fungi at a concentration of 30 µg/mL. The treated and control plates were incubated at 35 ± 2 °C for 24 h for bacterial strains and 28 ± 2 °C for 48 h for fungal strains respectively. The antimicrobial activity was determined by the presence of clear zone of inhibition around the paper discs. The inhibition zones were carefully measured using metric scale. Each treatment was conducted in triplicates and zone of inhibitions were expressed as average ± standard error. Negative controls were maintained using DMSO in order to study the solvent effect.

Minimum Inhibitory Concentration (MIC) of Essential Oils

The MICs were determined as the lowest concentration of leaf and fruit essential oils inhibiting visible growth of each tested organism. The MICs were measured by modified broth micro-dilution method [26] by using 96-well micro-titer plate. A Micro plate with nutrient broth media (100µl) was added to 1-9 wells. The test compound concentration was 10µl/ml in the first well, which is serially diluted from 1 to 8 and the 9 well acts as control. A fixed volume of 100µl overnight culture is added in all the wells and incubated at 37º C for 24 h and 27º C for 48 h for bacterial and fungal strains respectively. For fungal species MIC was determined by using the Potato dextrose agar plates pre-treated with different concentrations of the essential oil and observed for visible colonies. After incubation period, the micro plate was measured the absorbance with a multi-mode spectrophotometer (Tecan M 200 infinite micro plate reader) at 600 nm. Inhibition of bacterial growth in the plates containing test oil was determined by comparison with growth in control plates. Experiments were carried out in triplicate.

Determination of Anti-oxidant Activity

Table 4. DPPH scavenging potential of *C. caudata* leaf and fruit essential oils at various concentrations compared with ascorbic acid

Concentration	Leaf oil	Fruit oil	Ascorbic acid
5 µL	3.0 ± 0.5	6.2 ± 1.1	76.4 ± 5.3
10 µL	24.9 ± 3.7	39.5 ± 3.4	95.8 ± 7.2
15 µL	40.9 ± 4.1	59.8 ± 2.8	96.1 ± 6.4
20 µL	70.7 ± 3.4	97.2 ± 1.1	96.2 ± 4.7

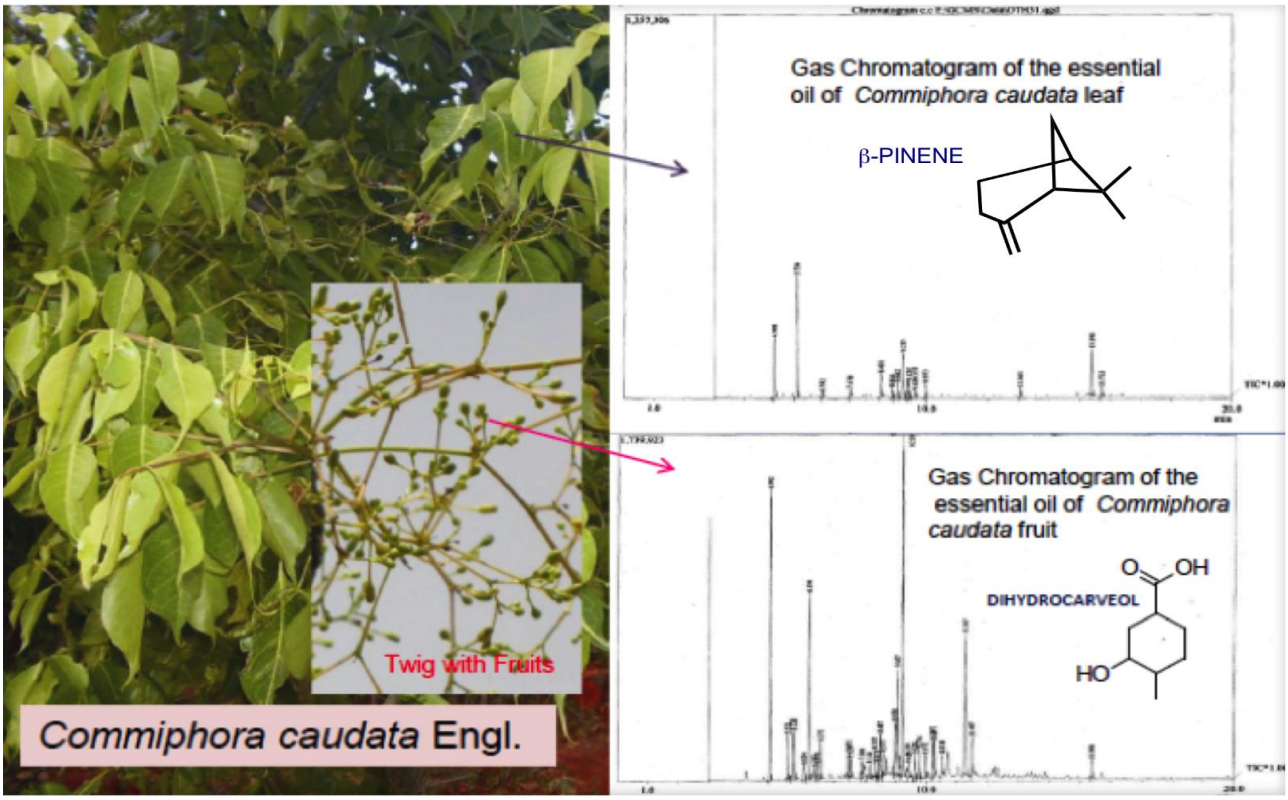

Figure 1. *Commiphora caudate* A. *Commiphora caudate* leaf, B. fruit (inset), C and D major chemical compound from the leaf and fruit.

Total Anti-oxidant Capacity

For total anti-oxidant capacity assay, 10 µL of undiluted essential oil was dissolved in methanol and mixed with 1 mL of reagent solution (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). The reaction tubes were capped and incubated in a thermal block at 95 °C for 90 min. After cooling to room temperature, the absorbance of the aqueous solution for each treatment was measured at 695 nm. Ascorbic acid was used as the standard and the total anti-oxidant capacity is expressed as equivalents of ascorbic acid [27].

1, 1-Diphenyl-2-Picrylhydrazyl (DPPH) Scavenging Activity

The anti-oxidant activity of the essential oils was assessed through DPPH (purchased from Sigma-Aldrich, USA) scavenging potential with ascorbic acid as the standard [28, 29]. Twenty micro-liters of various concentrations of leaf and fruit oils in methanol (purchased from E-Merck, India) were added to 1 mL of 0.004% methanol solution of DPPH. The reaction tubes were wrapped in aluminum foils and incubated at room temperature for 15 min in the dark then, the absorbance was read at 517 nm. All readings were recorded in dim light [30]. The percent (%) inhibition of free radical (DPPH) was calculated using the formula:

Inhibition (%) of DPPH = $[(A_c-A_s)/A_c] \times 100$

Where, A_c is the absorbance of the control (containing all reagents except the test sample/standard) and A_s is the absorbance of the test sample. Essential oil concentration providing 50% inhibition (IC_{50}) was calculated from the standard graph plotted using inhibition percentage against concentration.

Statistical Analysis

All the tests were carried out in triplicate. The data were statistically analysed by analysis of variance (ANOVA) technique using Windostat 8.5 advanced statistical software.

RESULTS

Chemical composition of leaf essential oil

The leaves of *C. caudata* produced 2.7 mL/kg pale-yellow coloured essential oil with mango-like odour. Fifteen constituents were identified and listed in Table 1. Monoterpene hydrocarbons (51.54%) i.e. cychlofenchene (17.84%) and β-pinene (33.70%) were the major compounds. α-Terpineol (10.40%), verbenol (5.40%), 4-terpineol (3.79%), myrtenol (3.73%), myrtenal (3.45%), linalool acetate (2.61%), thujen-2-one (2.02%), β-linalool (1.48%), 2-pinene-4-one (1.37%) and 1,8-cineole (0.94%) were the oxygenated monoterpenes accounting for 35.19% of the oil. Other compounds identified in the oil were: sesquiterepene hydrocarbon caryophyllene (1.66%) and oxygenated sesquiterpenes (11.61%) caryophyllene oxide (9.82%) and ledol (1.79%).

Chemical composition of fruit essential oil

C. caudata fruits yielded 10.0 mL/kg colourless aromatic oil with mango-like aroma. Twenty-eight components were identified and listed in Table 1. The volatile oil contained monoterpene hydrocarbons (32.56%) and oxygenated monoterpenes (50.32%) which were predominated by cychlofenchene (16.97%),

dihydrocarveol (19.58%), 3-carene (9.90%) and verbenone (8.18%).

Other compounds that present in >1% were: phenylacetone (3.75%), β-pinene (2.58%), 2(10)-pinene-3-ol (2.51%), 1,8-cineole (2.05%), thujen-2-one (1.91%), verbenol (1.73%), carveol (1.37%), β-linalool (1.23%), 1-nonanol (1.20%), linalool acetate (1.15%), melilotal (1.12%), *p*-mentha-1,3,8-triene (1.11 %), *tert*-butilbenzene (1.11 %) and α-campholenal (1.00%). Nonanal (0.91%), *cis-p*-mentha-2,8-dienol (0.90%), *d*-limonene (0.89%), myrtenal (0.87%) and myrtenol (0.86%) were the minor components. Interestingly sesquiterpene hydrocarbons were not detected and only one oxygenated sesquiterpene caryophellene oxide (0.96%) was recorded along with two aromatic compounds i.e. *m*-cymene (2.62%) and *p*-cymene-8-ol (6.05%) constituting 8.67% of the fruit essential oil.

Anti-microbial Activity

Anti-microbial activity of the leaf or fruit oils against 6 microorganisms is appended in Table 2. The oils exhibited concentration dependent inhibition activity which was clearly correlated with decreased activity with increased dilution. The essential oil exhibited strong inhibition on the growth of tested microbial strains except *C. albicans.* Interestingly one gram-positive bacterium namely, *S. aureus* and fungal species, *C. rugosa* were more sensitive to the essential oils when compared to the standard antibiotics. Negative control showed no activity (data not presented). Further, to determine minimum inhibitory concentration (MIC) of the test pathogens a small portion of culture was transferred from the zone of inhibition formed in petri dishes, to the freshly prepared sterile broth in 96 micro-well plate. The culture was incubated at 37 °C to 4 hours after addition of 10 µL of 5% MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide). The development of violet color indicates viable cells. The data presented in (Table 3).

Anti-oxidant and Free Radical Scavenging Activity

Total antioxidant capacities of *C. caudata* leaf and fruit essential oils were measured using ammonium molybdate reduction assay in terms of ascorbic acid equivalents (AAE). Total antioxidant capacity of the oil samples was 18.07± 2.71 and 184.33 ± 5.6 g/kg AAE/mL of oil, respectively.

The free radical scavenging assay was measured by calculating the optical density of DPPH at 515 nm using spectrophotometerand anti-oxidant activity of leaf essential oil at various concentrations (5, 10, 15 and 20 µL). With increase in concentration the scavenging capacity was also enhanced. The concentration of the essential oil that causes 50% inhibition of DPPH is known as IC_{50} and the IC_{50} values were calculated and reported in Table 4.

DISCUSSION

The present investigation focused on the chemical characterization, antimicrobial and antioxidant activities of essential oil obtained from the leaves and fruits of *C. caudate* (Figure 1), which is used as herbal recipe in folk medicine. Fruits yielded more oil with higher number of constituents relative to leaves. Out of the 33 identified components, 10 constituents were common in both the oils though their quantities differed. β-Pinene and dihydrocarveol were the chief constituents of leaf and fruit oils, respectively (Figure 1). The oils shared cyclofenchene as a major constituent though the other components varied markedly. Leaf oil abunded in monoterpene hydrocarbons, while oxygenated monoterpenes were the predominant compounds in fruit oil. It is known that certain aromatic plants produce essential oils from different plant parts that differ markedly in their chemical profiles [31, 32].

Leaf oil is a rich source of β-pinene and constitutes about 33.03%, is an important flavour and fragrance ingredient finding application in several industries. Cychlofenchene, β-pinene, α-terpineol, verbenol, 4-terpineol, caryophyllene and caryophyllene oxide were reported in the essential oils of various species of *Commiphora* [33]. *C. caudata* leaf and fruit essential oils exhibited concentration dependent anti-microbial activity. Concentration dependent anti-fungal [34] and anti-bacterial [35-37] activities of essential oils of other plant species were previously recognized. Both the oils displayed moderate to strong activity against the tested organisms. Especially the oils were more effective against *S. aureus* and *C. rugosa. B. subtilis* and *C. albicans* were relatively less sensitive to the oils. Differential anti-bacterial and anti-fungal activities of essential oils of aromatic plant species are known [38, 39] because of their differences in chemical composition and active constituents. Structure, functional groups, water-solubility, hydrogen-bounding capacity etc. determines the anti-microbial properties of essential oil constituents[40]. However, fruit oil showed better activity to the standard anti-fungal drug Amphotericin B against the fungus *C. rugosa* and which was comparable to the essential oil of aromatic crop rose-scented geranium (*Pelargonium* species) and its constituents displayed better anti-fungal activity relative to several anti-fungal drugs including Amphotericin B[38.] To the best of our knowledge this is the first detailed report on the leaf and fruit essential oils of *C. caudata*.

Natural essential oils being safer than synthetic pharmaceuticals hold promise as future pharmaceuticals for curing diseases caused by pathogenic bacteria and fungi. Presence of β-pinene, α-terpineol [41,42], α-terpineol, linalool acetate, 1,8 cineole [42,43], caryophyllene [44,45] in the essential oils tested were reported to possess anti-microbial activity against several bacteria and fungi strongly supports the results of the presnt investigation. In addition 1,8-Cineole and *d*-limonene were shown to inhibit feeding or oviposition of insects [46]. The presence of these constituents may be responsible for strong antibacterial and antifungal activity of *C. caudata* leaf and fruit oils. Predominance of oxygenated monoterpenes[40], presence of higher number of compounds, and their additive or synergistic activity is possibly responsible for the better activity of fruit oil. The potential antimicrobial activity of *C. caudata* fruit essential oil justifies its medicinal use of fruits for wound

healing by local tribal communities (The Wealth of India). Similarly, anti-bacterial and anti-oxidant activities of *C. caudata* leaf extracts were demonstrated earlier [4,5,8]. This is the first report on the chemical profile, anti-microbial and anti-oxidant activities of *C. caudata* leaf and fruit essential oils. The presence of antioxidant and antimicrobial activities in the essential oils strongly supports use of fruits in preparation of pickles in the tribal communities which provide protection to their health by providing immunity. MIC data of leaf and fruit essential oils corroborates with the data obtained on inhibition zones against the pathogens. Fruit oil demonstrated strong antimicrobial activity (MIC values between 3.33 and 10.00 µg/mL) relative to leaf oil (MIC values between 4.17 and 10.00 µg/mL) possibly due to the additive/synergistic activity of higher number of constituents present in the oil samples. *In vitro* antioxidant study results showed that fruit oil exhibited more ammonium molybdate dependent antioxidant activity and strong DPPH quenching property than leaf oil. This might be due to the presence of monoterpene hydrocarbons that were shown to possess anti-oxidant activity [47]. These results strongly supports the use of *C. caudata* fruits in pickles preparation, which may act as potential antioxidant agent.

CONCLUSIONS

Thirty-three constituents were identified in fruit and leaf essential oils of *C. caudata*. Fruits yielded more oil with higher number of constituents. β-Pinene and cyclofenchene were the chief constitutes of leaf oil. Dihydrocarveol and cyclofenchene were the principal constituents of fruit oil. Out of 4 bacteria and 2 fungi, *S. aureus* and *C. rugosa* were more sensitive to both the oils. Both the oils displayed anti-oxidant property, which finds application in preparation and storage of food materials. Fruit oil exhibited better anti-microbial and anti-oxidant activities, therefore holds promise for further investigations.

REFERENCES

1. Nayar SL, Chopra RN, Chopra IC. Glossary of Indian Medicinal Plants. Council of Scientific and Industrial Research, New Delhi 1956; 1:197.
2. McDowell PG, Lwande WS, Deans G, Waterman PG. Volatile resin exudate from stem bark of *Commiphora rostrata*, potential role in plant defence. Phytochemistry 1988; 27:2519–2521.
3. CSIR. The Wealth of India: raw materials. Council of Scientific and Industrial Research (CSIR), New Delhi, India 1950; 2:177.
4. Latha S, Selvamani P, Sen DJ, Gupta JK, Pal TK, Gosh AK. Antibacterial activity of *Commiphora caudata and Commiphora berryi* leaves. Indian Drugs 2005; 42:696-698.
5. Latha S, Selvamani P, Pal TK, Gupta JK, Ghosh LK. Pharmacognostical studies on leaves of *Commiphora caudata* (Wight et Arn.) Engl. Ancient Science of Life 2006; 26:19-25.
6. Sivakumar T, Kannan K, Kannappan N, Kathiresan K. Anti-inflammatory activity of *Commiphora caudata* (Wight and Arn.) Asian Journal of Chemistry 2009; 21:4130-4132.
7. Annu W, Latha PG, Shaji J, Anuja GI, Suja, SR, Shyamal S, Shine VJ, Rajasekaran S. Anti-inflommatory, analgesic and anti-lipid peroxydation studies on the leaves of *Commiphora caudata* Engl. Indian Journal of Natural Product Resources 2010; 1:44-48.
8. Sudarshana V D, Suresh Kumar P, Latha S, Selvamani P, Srinivasan S. Antioxidant studies on the ethanolic extract of *Commiphora* spp. African Journal of Biotechnology 2009; 8:1630-1636.
9. Nanthakumar R, Stephen S, Ambrose S, Sriram E, Babu G, Chitra K Uma Maheswara Reddy C. Effect of bark extract and gum exudate of *Commiphora caudata* on aspirin induced ulcer in rats. Pharmacognosy Research 2009; 11:375-380.
10. Robak J, Gryglewski RJ. Bioactivity of flavonoids. Polish journal of pharmacology and pharmacy 1996; 48:555-564.
11. Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils – A review. Food and Chemical Toxicology 2008; 46:446-475.
12. Aeschbach R, Loliger J, Scott BC, Murcia A, Butler J, Halliwell B, Aruoma OI. Antioxidant actions of thymol, carvacrol, 6-gingerol, zingerone and hydroxytyrosol. Food and Chemical Toxicology 1994; 32:31-36.
13. Ruberto G, Barrata MT. Antioxidant activity of selected essential oil components in two lipid model systems. Food Chemistry 2000; 69:167-174.
14. Cabrera J, Prieto M. Application of artificial neural networks to the prediction of the antioxidant activity of essential oils in two experimental in vitro models. Food Chemistry 2010; 118:141-146.
15. Hinneburg H, Damien Dorman J, Hiltunen R. Antioxidant activities of extracts from selectedculinary herbs and spices. Food Chemistry 2006; 97:122-129
16. Suhaj M. Spice antioxidants isolation and their antiradical activity: a review. Journal of Food Composition and Analysis 2006; 19:531–537.
17. Romano CS, Abadi K, Repetto MV, Vichera G, Vojnov AA, Moreno S. Study of bioactive compounds from plants of *Rosmarinus officinalis* L. with antioxidant activity. Molecular Medicinal Chemistry 2006; 11:43-46.
18. Lu Y, Foo LY. Antioxidant activities of polyphenols from sage (*Salvia officinalis*), Food Chemistry 2001; 75:197-202.
19. Sahin F, Gulluce M, Daferera D, Sokmen A, Sokmen M, Polissiou M, Ggar G, Oger H. Biological activities of the essential oils and methanol extract of Origanum vulgare ssp. vulgare in the Eastern Anatolia region of Turkey. Food Control 2004; 15: 549–557.
20. Clevenger JF. Apparatus for the determination of essential oil. Journal of the American Pharmacists Association 1928; 17:345-349.

21. Kovats E. Gas chromatographic characterization of organic substances in the retention index system. Advances in Chromatography 1965; 1:229–247,
22. Jennings W, Shibamoto T. Qualitative Analysis of Flavor and Fragrance Volatiles by Glass Capillary Gas Chromatography. Academic Press, New York. 1980.
23. Adams RP, Identification of Essential Oil Components by Gas Chromatography/Mass Spectroscopy. Allured Publishing Corp. Carol Stream, IL. 2001.
24. McFarland J. Standardization of bacterial culture for the disc diffusion assay. Journal of the American Medical Association 1987; 49:1176-1178.
25. NCCLS. Clinical and Laboratory Standards Institute formerly National Committee for Clinical Laboratory Standards. Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically, Wayne, PA 2008.
26. Delaquis PJ, Stanich K, Girard B, Mazza G. Antimicrobial activity of individual and mixed fractions of dill, cilantro, coriander and eucalyptus essential oils. International Journal of Food Microbiology 2002; 74:101-109.
27. Preito P, Pineda M, Aguilar M. Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: Specific application to the determination of vitamin E. Analytical Biochemistry 1999; 269:337–341.
28. Burits M, Bucar F. Antioxidant activity of *Nigella sativa* essential oil. Phototherapy Research 2000; 14:323–328.
29. Cuendet M, Hostettmann K, Potterat O. Iridoid glucosides with free radical-scavenging properties from Fagraea blumei. Helvetica Chimica Acta 1997; 80:1144–1152.
30. Sharma OP, and Bhat TK. DPPH antioxidant assay revisited. Food Chemistry 2009; 113:1202-1205.
31. Kaul PN, Bhattacharya AK, Rajeswara Rao BR, Syamasundar KV, Ramesh S. Volatile constituents of essential oils isolated from different parts of cinnamon *(Cinnamomum zeylanicum* Blume). Journal of the Science of Food and Agriculture 2003; 83:53-55.
32. Ravikiran S, Bhavani K, Sita Devi P, Rajeswara Rao BR, Janardhan Reddy K. Composition and larvicidal activity of leaves and stem essential oils of *Chloroxylon swietenia* DC. against *Aedes aegypti* and *Anopheles stephensi*. Bioresource Technology 2006; 97:2481-2484.
33. Hanus LO, Rezanka T, Bembitsky VM, Moussaieff A. Myrrh - *Commiphora* chemistry. Biomed Papers 2005; 149: 3–28.
34. Sampurna T, Nigam SS. Efficacy of some Indian essential oils against *Trichophyton mentagrophytes, Malabranchea pulchella* and *Keratiniphyton terreum* at different concentrations. Indian Drugs 1979; 14:29-30.
35. Hammer KA, Carson CF, Riley TV. Antimicrobial activity of essential oils and other plant extracts. Journal of Applied Microbiology 1999; 86:985-990.
36. Jirovetz L, Eller G, Buchbauer G, Schmidt E, Denkova Z, Stoyanova AS, *Radosveta* N, Margit G. Chemical composition, antimicrobial activities and odour description of some essential oils with characteristic floral rosy scent and their principal aroma compounds. Recent Research Development Agronomy and Horticulture 2006; 2:1-12.
37. Adinarayana G, Rahul G, Ravi Kiran S, Syamasundar KV, Rajeswara Rao BR. Evaluation of antimicrobial potential of field distilled and water-soluble essential oils of *Cymbopogon flexuosus*. Journal of Pharmacognosy 2012; 3: 142-146.
38. Rath, CC. Dash SK, Rajeswara Rao BR. Antifungal activity of rose-scented geranium (*Pelargonium* species) essential oil and its six constituents. Journal of Essential Oil Bearing Plants, 2005; 8:218-222.
39. Rajeswara Rao BR, Kothari SK, Rajput DK, Patel RP, Darokar MP. Chemical and biological diversity in fourteen selections of four *Ocimum* species. Natural Product Communications 2011; 6:1705-10.
40. Knobloch K, Weigand H, Weis N, Schwarm HM, Vigenschow H. Action of terpenoids on energy metabolism. In: Brunke EJ (Ed) Progress in Essential Oil Research, Walter de Gruyter, Berlin, 1986; 429-45.
41. Sokovic M, Marin PD, Brkic D, Van Griensven LJLD. Chemical composition and antibacterial activity of essential oils of ten aromatic plants against human pathogenic bacteria. http://www.baltikjunior.com/origano_doc/sinisa_stankovic_1.pdf accessed on 30 November 2012.
42. Magiatis P, Mellion E, Skahsounis AL, Chinou I, Mitaku S. Composition and antimicrobial activity of the essential oils of *Pistacia lentiscus* var Chia. In book of abstracts: 2000 years of natural products research – past present and future. Amsterdam: Leiden University 1999; 662.
43. Carson CF, Riley, TV. Antimicrobial activity of the major components of the essential oil of *Melaleuca alternifolia*. Journal of Applied Bacteriology 1995; 78:264–69.
44. Pattnaik S, Subramanyam VR, Bapaji M, Kole CR. Antibacterial and antifungal activity of aromatic constituents of essential oils. Microbios 1997; 89:39-46.
45. Perez C, Agnese AM, Cabrera JL. The essential oil of Scenecio graveolans (compositae) chemical composition and antimicrobial activity tests. Journal of Ethnopharmacology 1999; 66:91–96.
46. Whalon ME, Malloy GE. Insect repellent coatings. US patent 1998; 5, 843, 215.
47. Ruberto G, Baratta T. Antioxidant activity of selected essential oil components in two lipid model systems. Food Chemistry 2000; 69:167-74.