Chemical profiling of leaf essential oil, Antioxidant potential and Antibacterial activity of *Syzygium lanceolatum* (Lam.) Wt. & Arn. (*Myrtaceae*)

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ABSTRACT

Introduction: The present study was aimed to analyse the chemical composition, antioxidant potential and antibacterial activity in the leaf essential oil of *Syzygium lanceolatum* **Methods:** The essential oil was isolated by hydrodistillation method using a Clevenger type apparatus. The chemical composition of leaf essential oil was analysed by GC-MS. Antioxidant activity was determined by DPPH and ABTS radical scavenging assay. Antibacterial potential was tested against six bacterial strains. **Results:** GC-MS analysis revealed 2,8-Dimethyl-7-methylene-1,8-nonadien-3-yne (9.77%), Germacrene D (7.45%) as the major constituents and Linalool, β-Selinene (0.03%), Santalol (0.02%) were present in trace amounts. Maximum free-radical scavenging activity (69.97%) was observed at 500 ppm by the essential oil of *S. lanceolatum*, while the synthetic antioxidant Gallic acid showed 90.93% inhibition at the same concentration. The IC_{50} value of leaf essential oil and standard gallic acid were 219.24 ± 5.82 ppm and 159.84 ± 2.7 ppm respectively. In ABTS analysis, the oil showed the percentage inhibition in concentration dependent manner. 500 ppm concentration of oil showed 73.01% free-radical inhibition while the gallic acid exhibited 90.4% inhibition. The IC_{50} value of leaf essential oil and standard were 169.68 ± 3.09 ppm and 217.09 ± 0.70 ppm respectively. Antibacterial activity of leaf essential oil was tested against six bacterial strains and it was effective against all the strains. **Conclusion:** A total of 106 compounds were identified from the leaf essential oil and alkynes were the major class of compound, followed by the sesquiterpenes. The DPPH radical scavenging assay confirmed the antioxidant potential of the essential oil. Antibacterial activity tests proved that it is a potent growth inhibitor of pathogenic microbes. The present study throws light on the bioactive composition of *S. lancoelatum* essential oil and further studies will confirm the mode of action of these compounds.

Key words: ABTS, Antioxidant activity, DPPH, Essential oil, GC-MS, *Syzygium lanceolatum*.

INTRODUCTION

Essential oils are volatile, natural, complex secondary metabolites characterized by a strong odour and exert different biological activities on humans, animals and other plants.[1] The components of volatile oils consist of terpenes, terpenoids, phenol-derived aromatic components and aliphatic compounds. Essential oils play an important role in the plants as antibacterials, antivirals, antifungals, insecticides and also protect from herbivores by reducing their appetite for such plants. Despite their wide use and being familiar to us as fragrances, it is important to develop a better understanding of their mode of biological action for new applications in human health, agriculture and the environment. Some of them constitute effective alternatives or complement to synthetic compounds of the chemical industry.[2]

Syzygium lanceolatum (Syn.: *Eugenia lanceolata* Lam.; *Syzygium wightianum* Wall. ex Wt. & Arn.) belongs to the family Myrtaceae which includes 4,620 species and 140 genera distributed all over the world.[3] It has 10 genera and 154 species in the Indian subcontinent. Of these, *Syzygium* Gaertn. is the largest genus, having 1,200 species and 11 species are endemic to Western Ghats of Tamil Nadu, India.[4] Plants of this family are known to be rich in volatile

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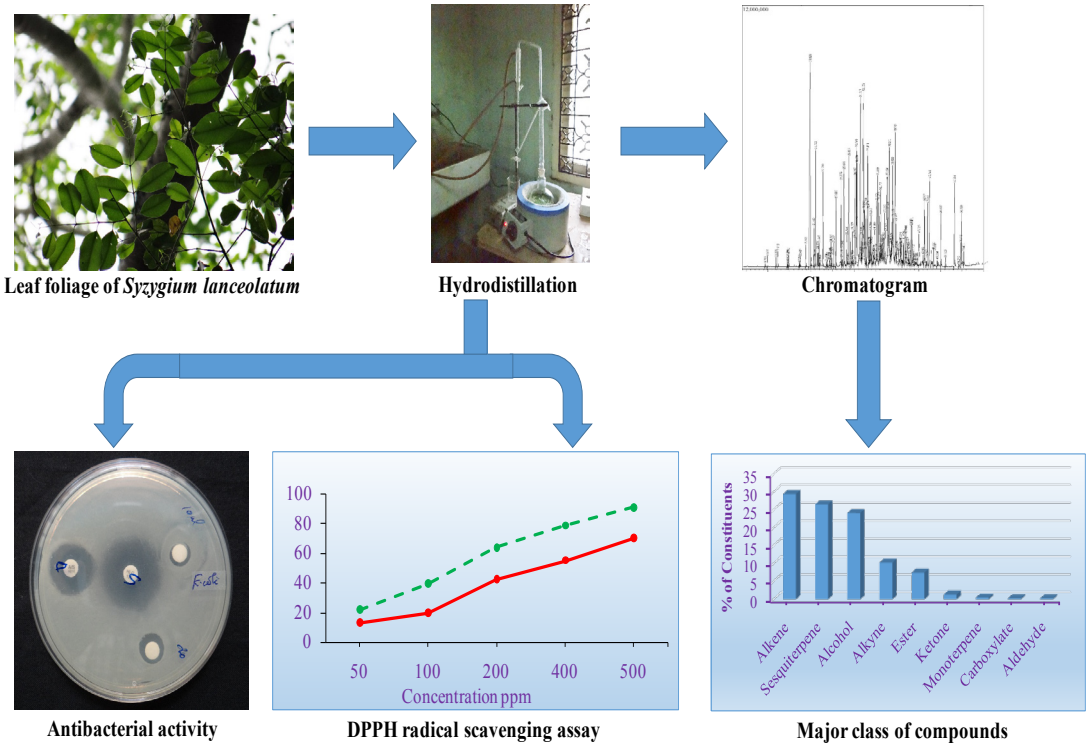

Graphical Abstract

oils which are reported for their uses in medicine and many fruits of this family has a wide range of history in usage, both edible and in traditional medicines.[5,6]

Several species of the family Myrtaceae are being used in folk medicine as antidiarrheal, antimicrobial, antioxidant, antirheumatic, anti-inflammatory, and cleansing agents. They are also used to decrease blood cholesterol level.[7] Most of *Syzygium* species are used to treat Diabetes mellitus. The chemical composition of essential oils from several species of *Syzygium* species was previously described in the literature, especially those from *S. aqueum, S. samarangense* and two varieties of *S. malaccense*; *S. aromaticum*; *S. guineense*; *S. caryophyllatum* and *Eugenia jambolana*.[8-15] Sesquiterpenes (hydrocarbon and oxygenated derivatives) were found to be the main class of volatile constituents possessing antibacterial, antifungal, anti-inflammatory and cytotoxic activities[16] in addition, monoterpenes and phenylpropanoids were also described in these oils.[17] A research work has been carried out to test the antioxidant activities of *Eucalyptus globulus* (Myrtaceae) and the results showed that the plant is extremely beneficial.[18] The critical review of earlier works proved that the family Myrtaceae is a potential source of natural antioxidants.

Chemical constituents having antioxidant activity were found in high concentrations in plants, especially in their volatile fraction[19] and to determine their significant role in the prevention of various degenerative diseases.[20] Clove (*Eugenia carophyllus*) essential oil exhibited scavenging activity at lower concentrations than eugenol, butylated hydroxytoluene (BHT), and butylated hydroxyanisole (BHA) concentrations.[21] In an another research work the antioxidant principle Rutin was isolated from the leaf ethyl acetate extract of *Memecylon edule* (Melastomataceae). This was confirmed by several assays and it can be used as a natural antioxidant in order to replace the synthetic antioxidants.[22] The antimicrobial activity of the essential oils from clove and rosemary (*Rosmarinus officinalis* L.) was tested alone and in combination.[23] In an another work, the chemical composition of clove essentials oil was identified by GC/MS analysis and its antimicrobial activity was studied against a large number of multi-resistant *Staphylococcus epidermidis*.[24] The antibacterial activity of *S. aromaticum* and its major component eugenol was tested against several Gram-positive (*Bacillus cereus*, *B. subtilis*, *Staphylococcus aureus*, *Enterococcus faecalis* and *Listeria monocytogenes*) and Gram-negative (*Escherichia coli*; *Salmonella typhi*; *S. choleraesuis*; *Yersinia enterocolitica*, *Pseudomonas aeruginosa*) bacterial strains.[25] There were no previous reports on the chemical composition and biological activities of leaf essential oil of *S. lanceolatum*. Hence, the aim of the present study was to identify the chemical composition as well as to analyze the antioxidant potential (by DPPH and ABTS assays) and antibacterial activities of *S. lanceolatum* leaf essential oil.

MATERIALS AND METHODS

Plant material

Syzygium lanceolatum leaves were collected from Sathuragiri hills of Western Ghats (9º 42´–9º 44´ N and 77º 37´–77º 41´ E) in Tamil Nadu, India. It is a mid-story tree, prominently distributed in wet evergreen forests at an elevation of 600 to1200 m. Voucher specimen collected from the field, was identified by regional flora[4,26] and confirmed at Botanical survey of India (Southern circle, Coimbatore). The herbarium specimen was prepared and then deposited in the herbarium of Department of Plant science, Madurai Kamaraj University, Tamil Nadu, India.

Hydrodistillation

The leaf essential oil was isolated from 200 g of fresh leaf sample. The leaves were first washed with tap water to remove the dust particles and then dried under fan for 10 minutes. The essential oil was isolated by hydrodistillation method using a Clevenger type of apparatus for 3 hours in 200 ml water at 100ºC temperature. The essential oil was carefully collected in a screw cap bottle and dried over anhydrous sodium sulphate. Essential oil was stored at -20°C until further analysis.

GC-MS Analysis

The chemical composition of the essential oil from the fresh leaves of *S. lanceolatum* was analyzed by GC/MS. A Shimadzu QP-2010 plus with thermal desorption system, TD 20 was used to obtain the chromatograms. The name and specification of the column used was Omega wax™ 250 (30 m × 25 mm × 25 µm film thickness). The temperature was programmed from 80°C with 2 minute initial hold to 200°C at 4°C/minute and 200°C-235°C at 8°C/minute and a final hold for 9 minutes at 235°C. The injector and detector temperature were set at 270°C and 250°C respectively and the split ratio was 1/60. Helium was used as carrier gas and the ionizing voltage was 70 eV. The compounds were identified based on the library search carried out using NIST and WILEY libraries.

Free-Radical Scavenging Ability (DPPH-assay)

Radical scavenging activity of *S. lanceolatum* leaf essential oil was determined spectrophotometrically.[27,28] 2 ml of different concentrations of essential oil and standard gallic acid (50-500 ppm) were prepared in methanol and add 1mM methanolic DPPH [1,1-diphenyl-2-picrylhydrazyl] solution to all the samples. Then the samples were shaken vigorously and kept at dark in room temperature for 30 minutes before measuring the absorbance at 517 nm against a reagent blank. The DPPH radical scavenging ability was calculated according to the following equation:

$$\% \text{ DPPH radical scavenging activity} = (Ao - A1)/ Ao \times 100\%,$$

where Ao is the absorbance of the control reaction and A1 is the absorbance in the presence of the standard or sample of the tested extracts. Percentage radical scavenging activity was plotted against the corresponding antioxidant substance concentration to obtain the IC_{50} value, which is defined as the amount of antioxidant substance required to scavenge 50% of free-radicals present in the assay system. IC_{50} values are inversely proportional to the antioxidant potential.

ABTS radical scavenging capacity

ABTS radical cation scavenging assay was carried out by the method of Re *et al*.[29] ABTS [2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)] radical cation was generated by adding 14 mM ABTS to 4.9 mM ammonium persulphate and the mixture was allowed to stand for 12-16hrs in the dark at room temperature. This solution was diluted to obtain an absorbance of 0.7 ± 0.05 with ethanol at 734 nm (Schimadzu UV-Vis spectrophotometer model 2450) and the same was used for further assay. To 900 µl of ABTS radical solution, add 100 µl of the leaf essential oil (50-500 ppm). The solution was shaken thoroughly and the absorbance was measured after 7 minutes. The capacity to scavenge the ABTS radical cation was calculated using the formula,

$$\text{ABTS radical cation scavenging capacity (\%)} = [(A1-A2)/ A1] X100$$

Where A1 is the absorbance of ABTS solution without test sample and A2 is the absorbance of ABTS solution with test sample. Gallic acid was used as reference compound.

Antibacterial Sensitivity tests

Antibacterial activity of *S. lanceolatum* leaf essential oil was investigated by the disc diffusion method.[30] Petri plates were prepared by pouring 20 ml of Mueller-Hinton agar medium (MHA) and allowed to solidify. The bacterial suspensions were then swabbed over the media surface using a sterile cotton swab to ensure confluent growth of the organism. Under sterile condition, 10 µL of different concentrations (50 ppm and 100 ppm) of the oil was impregnated on 6 mm sterile discs. The discs were then aseptically applied to the surface of agar plates. The zones of inhibition were measured after the incubation of 24 hours at 36°C. DMSO served as a negative control and antibiotic discs (6.0 mm

Table 1: Chemical constituents on the essential oil of *Syzygium lanceolatum*

R. Time	Percentage	Name of constituents
9.36	0.05	1-Octen-3-one
9.87	0.13	β- Myrcene
11.87	0.12	β-cis-Ocimene
12.31	0.19	β-cis-Ocimene
14.5	0.13	1,8-Nonadien-3-yne, 2,8-dimethyl-7-methylene¬
14.62	0.03	Linalool
14.82	0.17	Nonanal
17.28	0.06	1,8-Nonadien-3-yne, 2,8-dimethyl-7-methylene¬
17.48	0.15	3a,4,7,7a-tetrahydrodimethyl-4,7-methanoindene
18.81	0.36	Tricyclo[6.4.0.0(2,7)]Dodeca-2,12-diene
19.82	9.77	2,8-Dimethyl-7-methylene-1,8-nonadien-3-yne
20.06	0.14	Biphenylene, 1,2,3,6,7,8,8a,8b-octahydro-, trans¬
20.68	0.69	2-Methylenetricyclo[4.3.1.0~3,8~]dec-4-ene
21.07	2.41	1-Methylene-3-(2-propenylidene)-5-vinylcyclohexane
21.55	0.27	trans-Tricyclo[6.4.0.0(2,7)]Dodeca-2,12-diene
21.84	0.35	2,8-Dimethyl-5,8-tricyclo[5.3.0.0]decadiene
22.06	0.05	Cyclooctene, 4-methylene-6-(1-propenylidene)¬
22.78	2.45	Cyclohexane, 1-ethenyl-3-methylene-5-(1-propenylidene)¬
23.55	0.08	6,7-Dimethyl-1,2,3,5,8,8a-hexahydronaphthalene
23.82	0.1	Benzene, (1,3-dimethyl-2-butenyl)¬
24.26	0.1	2,8-Dimethyl-5,8-tricyclo[5.3.0.0]decadiene
24.39	0.17	(1-Methyl-penta-1,3-dienyl)-benzene
24.64	0.4	6,7-Dimethyl-1,2,3,5,8,8a-hexahydronaphthalene
24.82	0.12	Biphenylene, 1,2,3,6,7,8,8a,8b-octahydro-, trans¬
25.26	0.4	Bicyclogermacrene
25.82	1.16	α- Cubebene
26.95	1.54	α- Copaene
27.13	0.13	1,7,7-Trimethylbicyclo[2.2.1]hept-5-en-2-ol
27.3	0.2	β- Bourbonene
27.63	2.76	(1-Methylpenta-2,4-dienyl)benzene
28.34	0.77	(+)-Cycloisosativene
28.49	0.03	1,8-Nonadien, 2-methyl-5,7-dimethylen¬
28.81	2.28	E-Caryophyllene
29.17	0.5	β- Cubebene
29.38	0.09	α- Maaliene
29.57	0.61	Aromadendrene
29.75	0.09	Selina-5,11-diene
30.21	2.05	α- Caryophyllene
30.54	1.73	9-epi-β-Caryophyllene
30.67	1.26	2-Acetyl-5-methylfuran
31.06	0.19	Cadina-1(6),4-diene
31.5	7.45	Germacrene D
31.6	0.03	β-Selinene
31.68	0.26	α- Guaiene
31.79	0.16	Muurola-4(14),5-diene
32.17	6.78	Elixene
32.29	0.27	1,8-Cyclotetradecadiyne
32.43	1.44	.alpha.-Copaen-11-ol
32.71	0.87	γ- Cadinene
32.83	0.07	β- Himachalenoxide
33.15	3.8	δ- Cadinene
33.41	0.29	Cada-1,4-diene
33.6	0.25	α- Cadinene
33.76	0.57	Tricyclo[4.4.0.0(2,7)]dec-8-ene-3-methanol, .alpha.,.alpha.,6,8
33.91	0.76	Amorph-4-ene <1-alpha-, 10-alpha-epoxy->
34.02	0.08	β -Bourbonen-13-ol

34.18	0.27	β- Guaiene
34.35	0.02	β- Santalol
34.45	0.11	Epiglobulol
34.58	0.11	α-Muurolene-14-ol
35.2	1.64	Spathulenol
35.46	5.96	Viridiflorol
35.94	0.15	Tricyclo[4.4.0.0(2,7)]dec-8-ene-3-methanol, .alpha.,.alpha.,6,8
36.37	0.06	Humulene epoxide II
36.51	0.71	Ent-Spathulenol
36.69	0.25	Humulane-1,6-dien-3-ol
36.88	0.31	Rosifoliol
37.09	0.85	Epicubenol
37.25	0.51	α- Copaen-11-ol
37.69	4.15	Cadina-1(6),4-diene
37.86	0.82	Cadin-4-en-10-β-ol
38.2	3.43	Cadin-4-en-10-ol
38.67	0.28	α-Copaen-11-ol
38.92	1.89	Tricyclo[4.4.0.0(2,7)]dec-8-ene-3-methanol, .alpha.,.alpha.,6,8
39.03	0.45	Amorph-4-ene <1-alpha-, 10-alpha-epoxy->
39.56	3.73	Methyl (4Z,7Z,10Z,13Z,16Z,19Z)-4,7,10,13,16,19-docosahexaenoate
39.7	0.52	Calamenene
39.84	0.2	6-Isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro-2-naphthalenol
40.35	0.22	1,3-Cyclopentadiene, 5,5-dimethyl-1-ethyl¬
40.74	0.2	Cedren-13-ol, 8¬
40.83	0.2	6-(p-Tolyl)-2-methyl-2-heptenol
40.94	0.18	3-Pentadecylphenol
41.17	0.08	Dehydroaromadendrene
41.45	0.43	6-[1-(Hydroxymethyl)vinyl]-4,8a-dimethyl-1,2,4a,5,6,7,8,8a-octahydro-2-naphthalenol
41.77	0.54	14-hydroxy-alpha-muurolene
42.04	0.49	β-Copaen-4-α-ol
42.62	0.2	Laurene
42.88	0.11	Calamenene
43.18	0.72	1,7,7-Trimethyl-3-oxo-2-oxabicyclo[2.2.1]heptane-4-carboxylic acid, 2-(4-methylcyclohex-3-enyl)propyl ester
43.4	0.78	(Z)- β-santalol acetate
44.6	0.08	Farnesyl acetate
45.02	1.56	Acetic acid, 3-hydroxy-6-isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalen-2-yl ester
45.98	0.18	6,7-Dimethyltetralin
46.3	1.33	Aristola-1(10),8-diene
47.06	1.61	α- Copaen-11-ol
47.54	2.32	Dehydroaromadendrene
47.88	0.23	6-[1-(Hydroxymethyl)vinyl]-4,8a-dimethyl-1,2,4a,5,6,7,8,8a-octahydro-2-naphthalenol
48.42	0.27	Nuciferol acetate
49.28	0.12	7-(5-Hexynyl)tricyclo[4.2.2.0~2,5~]dec-7-ene
50.12	1	2-(4A,8-Dimethyl-2,3,4,4a,5,6-hexahydro-2-naphthalenyl)-2-propen-1-ol
51.2	0.14	Occidol
53.28	1.92	Phytol
54.23	0.05	Hexadecanaldiallylacetal
54.75	0.31	Ethyl (9z,12z)-9,12-octadecadienoate
54.89	0.81	9-Octadecenoic acid (z)-, ethyl ester
55.4	0.17	Octadecanoic acid, ethyl ester

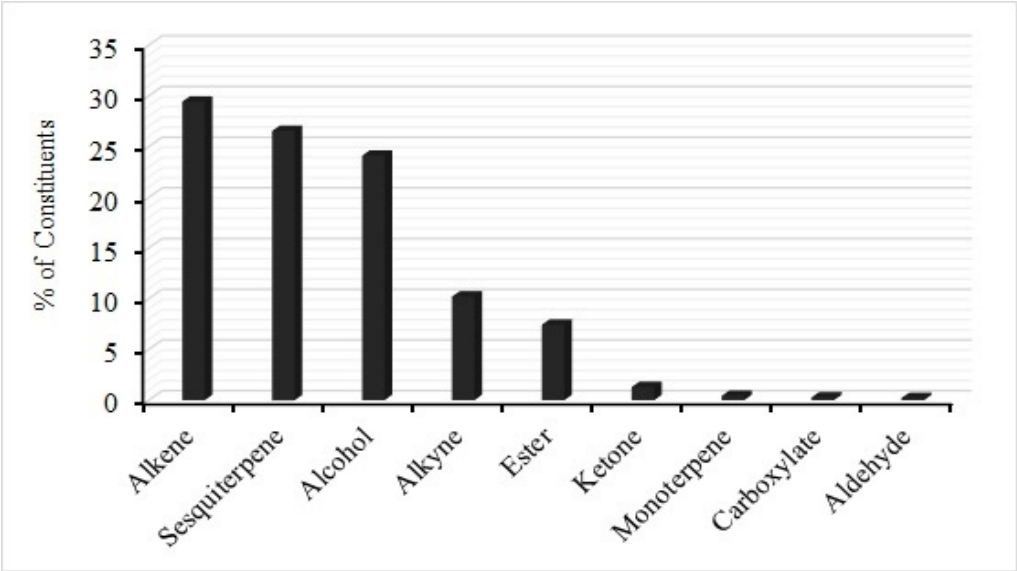

Figure 1: Percentage of major chemical constituent groups of *S. lanceolatum* leaf essential oil

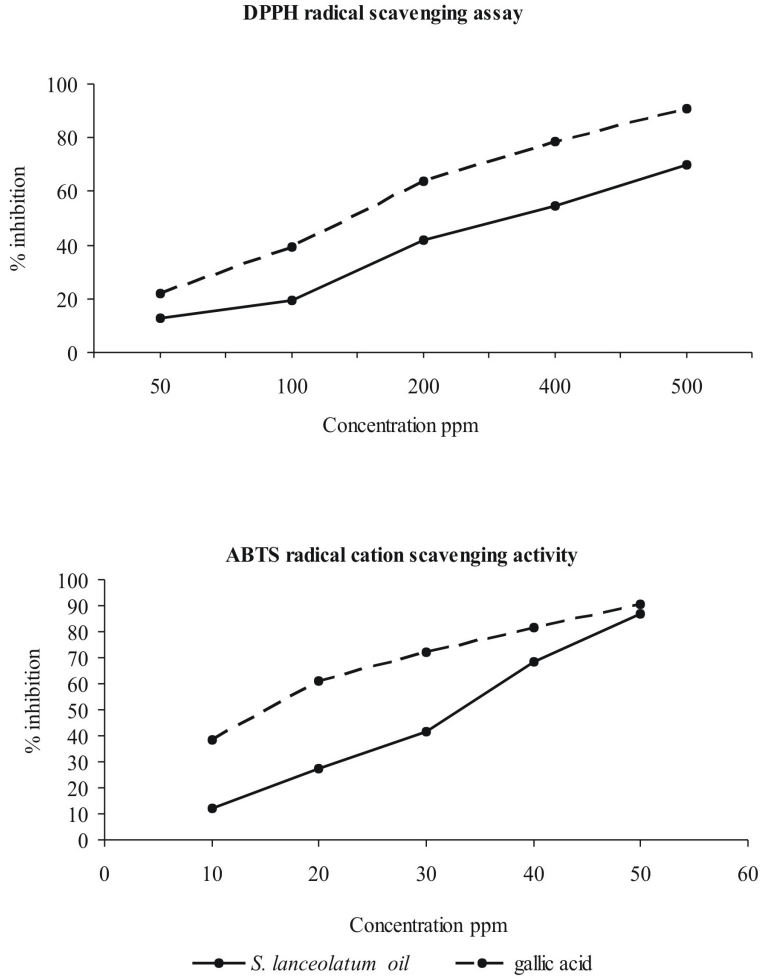

Figure 2: Antioxidant potential of *S. lanceolatum* by DPPH radical scavenging assay and ABTS radical cation scavenging activity

Table 2: Antibacterial activities of leaf essential oil of *S. lanceolatum*

Bacterial strains	50 ppm	100 ppm	Gentamycin (120 mcg/disc)	Ampicillin/ Sulbactum (10/10 mcg/disc)
S. aureus	9.3 ± 0.5	12.3 ± 0.5	21 ± 1.1	13.5 ± 1.5
S. hominis	10.8 ± 0.7	14.3 ± 0.5	28 ± 0.5	30 ± 0.5
A. viridans	10.3 ± 0.5	13.6 ± 0.5	24.5 ± 0.5	10 ± 1.5
E. coli	8.3 ± 0.5	13.3 ± 0.5	25 ± 0.5	10 ± 2.0
B. cereus	7.3 ± 0.5	12.6 ± 0.5	27 ± 1.1	9.5 ± 1.1
B. licheniformis	7.6 ± 0.5	13.0 ± 1.0	23 ± 1.0	31 ± 1.1

Values are given as mean ± SD n=3 ; Diameter of inhibition zones (mm) including disc size 6 mm.

in diameter) of 10/10 mcg/ml Ampicillin/Sulbactum, 120 mcg/ml Gentamycin were also used as positive controls. Antibacterial activity was evaluated by measuring the diameter of the zones of inhibition against tested bacteria.

Statistical analysis

All data were reported as mean ± standard deviation of three replicates. The IC_{50} values were calculated using the ED50 plus v 1.0 programme. Statistical analysis was performed using Microsoft Excel.

RESULTS

GC-MS analysis

Hydrodistillation of the fresh leaves from *S. lanceolatum* yielded yellow viscous oil with a strong odour (yield 0.2% v/w). A total of 106 compounds were identified (Table 1) representing 100% of the essential oil as analyzed by GC/MS. The major constituents identified in the essential oil of *S. lanceolatum* were 2,8-Dimethyl-7-methylene-1,8-nonadien-3-yne (9.77%), Germacrene D (7.45%) Elixene (6.78%) and Viridiflorol (5.96%). Linalool (0.03%), β-Selinene (0.03%) and β-Santalol (0.02%) were present in low concentrations. Alkenes (29.44%) were the major class of compounds, followed by Sesquiterpenes (26.56%) and Alcohols (24.12%). The concentration of Alkynes (10.23%), Ester (7.44%) compounds were comparatively low and the least represented compounds were Carboxylates (0.27%), Aldehydes (0.22%; Figure 1).

Free-radical scavenging activities

The free-radical scavenging ability of the essential oil of *S. lanceolatum* was determined by two different assay systems, namely, DPPH and ABTS (Figure 2). Maximum free-radical scavenging activity (69.97%) was observed at 500 ppm, while the synthetic antioxidant Gallic acid showed 90.93% inhibition at the same concentration in DPPH assay. The IC_{50} values of leaf essential oil and standard Gallic acid were 219.24 ± 5.82 ppm and 159.84 ± 2.7 ppm respectively. In the ABTS analysis, 500 ppm concentration of oil showed the 73.01% free-radical inhibition while the gallic acid exhibited 90.4% inhibition. The IC_{50} of leaf essential oil and standard gallic acid were 169.68 ± 3.09 ppm and 217.09 ± 0.70 ppm respectively. Both the assays showed a similar trend where the percentage inhibition increased with an increase in the concentration of both essential oil and the standard.

Antibacterial activity

Antibacterial activity of *S. lanceolatum* leaf essential oil was tested against six bacterial strains namely *B. cereus, B. licheniformis, S. aureus, S. hominis, A. viridian* and *E. coli.* It was observed that the leaf essential oil was effective against all the tested bacterial strains. The essential oil was active against both gram-positive and gram-negative bacteria with inhibition zones ranging between 7.3 mm and 14 mm (Table 2). The essential oil showed considerable growth inhibition when compared with standards Gentamycin and Ampicillin. The best zone of inhibition was detected at the concentration of 100ppm against *S. hominis* (14.3 mm), *E.coli* (13.6 mm) and *A. viridian* (13.3 mm).

DISCUSSION

Earlier reports suggested that eugenol is the major compound in the essential oil of *Syzygium* species. For instance, previous studies were revealed that the essential oil of *S. aromaticum* consisted 75% to 85% of eugenol.[31,32] Another study reported that the essential oil of same species possessed 68% and 49.0% of eugenol.[10,33] About 94.4% of Eugenol was present in the leaf essential oil of *S. aromaticum* from Little Andaman.[9] There was a significant difference in the contents of clove oil from Little Andaman and Indonesia, i.e eugenol (94.4, 71.0%), caryophyllene (2.9, 14.0%) and α-humulene (0.36, 1.75%).[34] On the contrary, the present study showed that 2, 8-Dimethyl-7-methylene-1, 8-nonadien-3-yne (9.77%) and Germacrene D

(7.45%) as the major constituents present in *S. lanceolatum* leaf essential oil. However, the chemical composition of essential oils varies depends upon the climatic factors, seasonality and geographic location.[13,35]

In the present study, the leaf essential oil of *S. lanceolatum* exhibited strongest DPPH free-radical scavenging activity i.e 69.97 % inhibition at the concentration of 500ppm, while the synthetic antioxidant Gallic acid showed 90.93% of inhibition at the same concentration. Whereas the leaf essential oil of *Syzygium caryophyllatum* showed free-radical scavenging activity with significant variation between winter (85.83%) and summer (83.36%).[13] Nassar *et al.* (2007) reported that 42-83 % of scavenging activity absorbed in the volatile extract of clove buds (*S. aromaticum*) in all the concentrations ranging from 50 to 400 µg/ml remarkably at higher concentration (400 µg/ml) showed greatest inhibition rate of DPPH radical scavenging activity (45 to 93 %).[12] According to ABTS analysis the oil revealed that the percentage inhibition was concentration dependent manner.

The leaf essential oil of *S. lanceolatum* was tested against six bacterial strains and it was found that the essential oil inhibited growth of all the bacterial strains studied. The best zone of inhibition was detected at the concentration of 100ppm against *S. hominis* (14.3 mm), *E.coli* (13.6 mm) and *A. viridian* (13.3 mm). The chemical constituent on flower buds of *Syzygium aromaticum* was capable to inhibit the growth of 36 bacterial strains isolated from ten types of freshwater and marine aquatic animals as well as seven ATCC reference bacterial strains. The minimum inhibitory concentration (MIC) values of the essential oil of *S. aromaticum* against the evaluated bacterial strains ranged from 0.015 µg mL^{-1} to 0.062 µg mL^{-1}.[10] The Minimum Inhibition Concentration value of essential oil of *S. aromaticum* against human pathogens; *Staphylococcus epidermidis*, *Escherichia coli* and *Candida albicans* ranged from 0.62 µg. mL^{-1} to 5 µg. mL^{-1}.[23] Other studies showed that the MIC value of the essential oil of *S. aromaticum* against human pathogens, four Gram-positive bacteria (*Staphylococcus aureus*, *Bacillus cereus*, *Enterococcus faecalis*, and *Listeria monocytogenes*) and three Gram-negative bacteria (*E. coli*, *Yersinia enterocolitica* and *Salmonella choleraesuis*) ranged from 17.5 µg. $mL^{-1}$to 131 µg. mL^{-1}, however, the essential oil failed to show inhibitory activity against *Pseudomonas aeruginosa*.[25]

CONCLUSION

S. lancoelatum is a relatively under-utilized plant which belongs to the family Myrtaceae, having food and nutraceutical potential. As there were no previous reports regarding chemical composition and biological activities of this plant, the present study concluded that the leaf essential oil of *S. lancoelatum* contains several phytochemical constituents having therapeutic value and stresses the need for further studies to assess the mode of action of the reported bioactive compounds.

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CONFLICT OF INTEREST

We do not have any conflict of interest in the present research work.

ABBREVIATIONS

DPPH : 1,1-diphenyl-2-picrylhydrazyl
ABTS : 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)
GC-MS: Gas chromatography-Mass spectrometry
DMSO : Di methoxy sulfoxide
MIC : Minimum inhibitory concentration
MHA : Mueller-Hinton agar medium

Highlights of the paper

- *Syzygium lanceolatum* (Lam.) Wt. &Arn.(Synonym: *Eugenia lanceolata* Lam.; *Syzygium wightianum* Wall. ex Wt. &Arn.), commonly calledas "vennaval" and it belongs to the family Myrtaceae.
- This plant is having high ethno-botanical value and used in the treatment for peptic ulcer.
- There is no previous reports regarding the bioprospecting of this important medicinal plant.
- Hence the present work has been carried out toassess Antioxidant potential and Antibacterial activity from leaf essential oil of *Syzygium lanceolatum*.

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REFERENCES

1. Adorjan B, Buchbauer G. Biological properties of essential oils: an updated review. Flavour Fragr. J. 2010; 25(6): 407–26.
2. Carson CF, Riley TV. Non-antibiotic therapies for infectious diseases. Communicable Diseases Intelligence Quarterly Report 2003; 27(suppl 2003): S143–6.
3. Mabberly DJ. The Plant Book. A Portable Dictionary of the Vascular Plants. 2nd ed.; Cambridge University Press: Cambridge, UK; 1997.
4. Gamble JS, Fischer CEC. Flora of the Presidency of Madras. Adlard and Son. London. Vols. I–III; 1923. 1915–35.
5. Mahmoud II, Marzouk MS, Moharram FA, El-Gindi MR, Hassan AM. Acylated flavonal glycoside from *Eugenia jambolana* leaves. Phytochemistry 2001; 58(8): 1239–44.
6. Reynertson KA, Basile MJ, Kennelly EJ. Antioxidant potential of seven myrtaceous fruits. Ethnobot Res Applic. 2005; 3: 25–35.
7. Stasi LCD, Hiruma-Lima CA. Plantas Medicinais na Amazonia e na Mata Atlantica, 2nd ed.; Editora Unesp: Sao Paulo, Brazil; 2002.
8. Wong KC, Lai FY. Volatile Constituents from the Fruits of Four *Syzygium* Species. Flavour Frag J. 1996; 11(1): 61–6.
9. Raina VK, Srivastava SK, Aggarwal KK, Syamasundar KV, Sushil Kumar. Essential oil composition of *Syzygium aromaticum* leaf from Little Andaman India. Flavour Frag J. 2001; 16(5): 334 -6.
10. Lee S, Najiah M, Wendy W, Nadirah M. Chemical composition and antimicrobial activity of the essential oil of *Syzygium aromaticum* flower bud (Clove) against fish systemic bacteria isolated from aquaculture sites. Front Agric China. 2009; 3(3): 332–6.
11. Noudogbessi J-P, Yedomonhan P, Sohounhloue DCK, Chalchat J-C, Figueredo G. Chemical composition of essential oil of *Syzygium guineense* (Willd.) DC. var. *guineense* (Myrtaceae) from Benin. Rec Nat Prod. 2008; 2(2): 33–38.
12. Nassar MI, Gaara AH, El-Ghorab AH, Farrag A-RH, Hui Shen H, Huq E. *et al*. Chemical Constituents of Clove (*Syzygium aromaticum*, Fam. Myrtaceae**)** and their Antioxidant Activity. Rev Latinoam Quim. 2007; 35(3): 47–57.
13. Bhuiyan NI, Begum J, Nandi NC, Akter F. Constituents of the essential oil from leaves and buds of clove (*Syzigium caryophyllatum* (L.) Alston). Afr J Plant Sci. 2010; 4(11): 451–4.
14. Stalin N, Swamy PS. Leaf Essential Oil Composition and Biochemical Activity of an Endangered Medicinal Tree *Syzygium caryophyllatum* (L.) Alston, (Wild black plum). J Essent Oil Bear Pl. 2013; 17(3): 371-9.
15. Ahmed F, Chandra JNNS, Timmaiah NV. An *In vitro* study on the inhibitory activities of *Eugenia jambolana* seeds against carbohydrate hydrolyzing enzymes. J Young Pharm. 2009; 1(4): 327-31.
16. Stefanello MEA, Pascoal ACRF, Salvador MJ. Essential oils from Neotropical myrtaceae: Chemical diversity and biological properties. Chem Biodiv. 2011; 8(1): 73–94.
17. Boulos L. Medicinal plants of North Africa. Reference publications, Algonac, MI; 1983.
18. Mishra AK, Sahu N, Mishra A, Ghosh AK, Jha S, Chattopadhyay P. Phytochemical Screening and Antioxidant Activity of essential oil of *Eucalyptus leaf*. Phcog J. 2010; 2 (16): 21-24.
19. Velioglu YS, Velioglu G, Mazza L, Gao B, Omach O. Antioxidant activity and total phenolics in selected fruits, vegetables and grain products. J Agric Food Chem. 1998; 46(10): 4113–7.
20. Willett FB, Willett WC. Optimal diets for prevention of coronary heart disease. J Am Med Assoc. 2002; 2888(20): 2569–78.
21. Jirovetz L, Buchbauer G, Stoilova I, Stoyanova A, Krastanov A, Schmidt E. Chemical composition and antioxidant properties of *clove leaf* essential oil. J Agr Food Chem. 2006; 54(17): 6303–7.
22. Srinivasan R, Natarajan D, Shivakumar MS. Antioxidant Compound Quercetin-3-O-α-L-rhamnoside(1→6)- β-D-glucose (Rutin) isolated from ethyl acetate leaf extracts of *Memecylon edule* Roxb (Melastamataceae). Free Rad Antiox. 2015; 5(1): 35-42.
23. Fu Y, Zu Y, Chen L, Shi X, Wang Z, Sun S, *et al*. Antimicrobial activity of clove and rosemary essential oils alone and in combination. Phytother Res. 2007; 21(10): 989-94.

24. Chaieb K, Hajlaoui H, Zmantar T, Kahla-Nakbi AB, Rouabhia M, Mahdouani K, *et al*. The chemical composition and biological activity of clove essential oil, *Eugenia caryophyllata* (*Syzygium aromaticum* L.). Phytother Res. 2007; 21(6): 501–6.
25. Lopez P, Snchez C, Batle R, Nern C. Solid- and vapor-phase antimicrobial activities of six essential oils: susceptibility of selected foodborne bacterial and fungal strains. J Agr Food Chem. 2005; 53(17): 6939–46.
26. Pascal JP, Ramesh BR. A Field Key to the Trees and Lianas of Evergreen Forest of the Western Ghats (India). Travaux de la Section Scientifique et Technique, Tome XXIII, Institut Français de Ponichery; 1987.
27. Shimada K, Fujikawa, K Yahara K, Nakamura T. Antioxidative properties of xanthan on the autoxidation of soybean oil in cyclodextrin emulsion. J Agric Food Chem. 1992; 40(6): 945-948.
28. Parasuraman S, Petchi RR, Vijaya C, Dhanaraj SA. Evaluation of free radical scavenging properties and hypoglycemic activity of ethanolic extract of *Tridax procumbens* Linn. in Wistar rats. Drug Dev Ther. 2014; 5(2): 164-7.
29. Re R, pellegrini N, Proteggente A, Pannala A, Yang M, Rice-evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic Biol Med.1999; 26(9): 1231–7.
30. Irbi ON, Moo-Young M, Anderson WA, Daramola SO. Antimicrobial activity of the bark of *Bridelia ferruginea* (*Euphorbiaceae*). Int J Pharmacog. 1994; 34(3): 87-90.
31. Bauer K, Garbe D, Surburg H. Common Fragrance and Flavor Materials: Preparation, Properties and Uses. Weinheim: Wiley-VCH; 2001. 293.
32. Farag RS, Daw ZY, Hewedi FM, El-Baroty GSA. Antimicrobial activity of some *Egyptian spice* essential oils. J Food Prot. 1989; 52(9): 665–7.
33. Kong QL, Song YZ, Zhang LL, Chen LY, Li QF. Natural antifungal compounds from *Syzyqium aromaticum* (L.) Merr. Et Perry. Acta Agric Shanghai. 2004; 20(3): 68–72.
34. Vernin G, Vernin E, Metzger J, Pujol L, Parkanyi C. GC-MS Analysis of clove essential oils. In *Spices Herbs and Edible Fungi*, Charalambous G (ed.). Elsevier Science: Amsterdam; 1994, 483–500.
35. Baydar H, Sagdic O, Ozkan G, Karadogan T. Antibacterial activity and composition of essential oils from *Origanum*, *Thymbra* and *Satureja species* with commercial importance in Turkey. Food Control. 2004; 15(3): 169–172.