Chapter-16

SUMMARY
India has long tradition of using aromatic plants in the holistic systems of medicines like Ayurveda and Unani. Aromatherapy deals with the use of essential oils as a cure to several ailments. Essential oils have therapeutic properties like antiseptic, sedative, anti-inflammatory, antispasmodic, antifungal, antiviral, stimulant, relaxant, diuretic, invigorating, euphoric and digestive. The system was brought to practice when antiseptic and skin permeability properties of essential oils were discovered. The methods used in aromatherapy are inhalation, local application and baths that allow the essential oils to enter the body and influence aura. Once within the body, the essential oils re-establish a close harmony where there is malfunction or lack of balance and revitalize the affected system.

In aromatherapy different blends of essential oils are used for various ailments like muscular aches and pain, respiratory problems, insomnia, headache, swollen joints, urinary problems, skin ailments, depression, indigestion etc. The essential oils become more effective when other aspects like lifestyle and diet are given due consideration. Present study has been undertaken to study the composition of various volatile oils used in aromatherapy and to evaluate their anti-microbial potential.

*Cinnamomum camphora* (Linn.) Presl. (Lauraceae) is an evergreen tree, native to China and Japan, introduced and cultivated in India as a source of camphor. The plant is considered sedative, anodyne, antiseptic, diaphoretic, anthelmintic, stimulant, and carminative and used in various insecticidal preparations. A hydro-distilled volatile oil from leaves and twigs was found to contain 26 components, 21 of which were completely identified (94.2%) while as five components were partially identified (5.5%). The oil was characterized by large amount of monoterpenes (85.6%). The main components were cis-pinane (20.7%), citronellal (15.3%), l-limonene (14.8%), dehydrosabinene (12.1%), limonene-1,2-epoxide (11.6%), pulegone (3%) and cis-ocimene (2.1%). Sesquiterpenic fraction is represented by only β-caryophyllene (0.9%). The major non-terpenic components were formic acid (3.7%), 4-methyl pentamide (2%) and palmitic acid (1.9%).
Cymbopogon citratus (DC.) Stapf. (Poaceae), commonly known as lemon grass, is considered to be of Indian origin but is now generally distributed in tropical and subtropical regions. The grass is pungent, bitter, sharp, hot; laxative, appetizer, alexipharmic, aphrodisiac, anthelmintic; useful in bronchitis, leprosy, epileptic fits, in flatulent and spasmodic affections of the bowels, and in gastric irritability. A hydro-distilled volatile oil on GLC and GC-MS analysis was found to contain 25 components amounting to 97.8% of total volatiles. The oil was characterized by a high percentage of monoterpene fraction, amounting to about 91%, dominated by ten oxygenated monoterpenes (86.7%). Neral (41.7%) was the main constituent followed by nerol (23.6%), 1,8-cineole (9%) and geraniol (6.9%). Monoterpene hydrocarbon amounting to 4.4% consisted of 3, 7-dimethyl-1, 6-octadiene, myrcene, p-cymene, l-limonene and E-(β)-ocimene. The Sesquiterpene fraction is represented by three hydrocarbons (2.8%) that consisted of mainly trans-β-caryophyllene (2.3%).

Cymbopogon nardus Linn. (Non-Rendle) (Poaceae) syn. Andropogon nardus Linn., commonly known as citronella grass, is distributed throughout the hotter parts of India, Burma, Malaya Peninsula, Sri Lanka, tropical Asia, Africa and Australia. The infusion of the leaves is used as a stomachic and carminative. The oil possesses stimulant, carminative, antispasmodic and diaphoretic properties. GLC and GC-MS analysis of citronella oil resulted in identification of 28 components comprising of 99.7% of total volatiles. Quantitatively the oil was characterized by higher percentage of sesquiterpenes (80.3%) than the monoterpenes (14.2%). Sesquiterpene fraction consisted of seven hydrocarbons (73.8%) and eight oxygenated sesquiterpenes (6.5%). Valencene (about 37%) was found to be the predominant component followed by α-c-bergamotene (19.4%), γ- and δ-cadinene (9.3%), trans-β-caryophyllene (5.8%), l-nerolidol (3.4%) and β-selinene (2.1%). The monoterpenic fraction consisted of four hydrocarbons (4.5%) and five oxygenated monoterpenes (9.7%). 1,8-Cineole (6%) was the main monoterpenic component followed by myrcene (2.9%), terpinyl acetate (2.9%) and cis-ocimene (0.7%). Four non-terpenic components (about 5%), consisted mainly of formic acid (3.1%), 2-methyl-1-butamine (0.9%) and bis-1,2-benzene dicarboxylic acid (0.9%).

SUMMARY
Eucalyptus citriodora Hook. (Myrtaceae) is among the economically important species of eucalyptus available worldwide. Its main utility is in the perfume industry due to its highest citronellal content (>70%). Its physical aromatherapy uses include athletes' foot, cut and wounds, bronchitis, muscular aches, cold and flu. It is particularly useful for the respiratory system. Analysis of the oil by GC-MS resulted in complete identification of 22 components out of 30, comprising 99% of the total volatiles. Quantitatively the oil was characterized by a high amount of monoterpenes identified, there were 9 monoterpenic hydrocarbons (44.3%), 2 monoterpenic alcohols (3.8%) and an aldehyde (16.2%). The predominant monoterpenic being sabinene (23.4%) followed by citronellal (16.2%), α-thujene (13.1%), p-cymene (6.4%) and α-terpineol (2.4%). Among 10 sesquiterpenes identified (30.5%) there were 4 sesquiterpenic hydrocarbons (4.7%) and 6 sesquiterpenic alcohols (25.8%). The predominant sesquiterpene was globulol (11.8%) followed by cpm-globulol (8.3%), elemol (5.4%) and β-caryophyllene (3.7%).

Jasminum grandiflorum (Oleaceae) syn. Jasminum officinale is native to southwest Asia. It is widely grown in gardens throughout India. In Ayurvedic medicine, jasmine is recommended for cleansing the blood. Jasmine oil is uplifting and stimulating. The aroma acts as an antidepressant. It can be used in skin care preparations for its excellent perfume and invigorating power. GLC and GC-MS analysis of the oil resulted in the isolation of 25 components (about 98%). The oil was found to contain eleven monoterpenes (25.4%) of which two were hydrocarbons (0.6%) and nine were oxygenated derivatives (24.8%). Menthofuran (15%) was the main monoterpenic followed by cis-3-pinen-2-ol (2.5%), trans-verbenol (1.9%), 4-terpinylacetate (1.9%) and linalool (1.6%). Sesquiterpene fraction was represented by 1-nerolidol (0.2%) and caryophyllene (<0.1%). The non-terpenic fraction makes the major part of the total volatiles (about 72%). The present study reports the benzyl butyrate as the main non-terpenic compound (56.3%) instead of benzyl acetate, which is present in considerably lesser amount (3.7%). Other important components of the same category are benzyl-hex-2, 4-dien-1-ol (10.3%) and pentan-1, 2-diol (1%).
Jasminum sambac Linn. (Oleaceae) is a scandant or sub-erect shrub found through out India. The plant is much valued for its exquisitely fragrant flowers and is cultivated nearly through out the tropical and sub-tropical parts of the world. A decoction of the leaves is used for fevers. Leaves are applied as poultices for skin complaints and ulcers. Roots are used with leaves in eye lotions and as emmenogogue. Flowers are lactifuge in action and are applied to breasts to arrest secretion of milk in puerperal state in case of threatened abscess. GLC and GC-MS analysis of the oil resulted in the isolation of 20 components (99.5%) of which 18 were completely characterized (99.1%), one component partially identified (0.1%), while as one component remained unknown (0.3%). The monoterpenic fraction consisted of one hydrocarbon, namely α-terpinolene (4.6%) and eight oxygenated monoterpenes (60.5%). The main oxygenated component was campholenic acid (26.6%) followed by α-terpineol (10.9%), 1-verbenol (9%), trans-pinocarveol (9%) and linalool (4.4%). The sesquiterpene fraction consisted of two hydrocarbons and one oxide. α-Selinene (13.1%) and caryophyllene oxide (13.2%) were the main components along with aromadendrene, which was found in traces only. The notable presence of pleasant smelling α-selinene is an important fact as this is a valuable aroma component. Six non-terpenic components (8.1%) mainly consisted of benzyl-hex-2,7-dien-1-oate (4.1%), benzyl butyrate (2.9%) and several acids. Presence of benzyl butyrate along with several oxygenated terpenic components attribute a characteristic odour to the oil.

Lavandula officinalis Mill (Lamiaceae) is a native of the mountainous regions of Southern Europe bordering on the western half of the Mediterranean and extending from the eastern coast of Spain to Calabria (Italy) and North Africa. Attempts have been made to cultivate lavender in India. Cultivation on an experimental scale has been under-taken at several places in Kashmir at altitudes of 1500 m and the results are promising. It is a natural antibiotic, antiseptic, antispasmodic, sedative and detoxifier, which promotes healing and prevents scarring. It may be used to clean cuts, bruises and skin irritations. It is also anti-inflammatory, analgesic, anti-infectious, cardiotonic, hypotensive and anticoagulant. Analysis of the oil by GLC and GC-MS methods resulted in identification of 24 components representing 61.7% of total volatiles. Out of these 22 components

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(about 60%) were completely identified while one component (0.7%) was partially identified and another one (1.4%) remained unknown. Quantitatively the oil was characterized by large amount of monoterpenes (57.2%), which comprised of three hydrocarbons (4.8%) and twelve oxygenated monoterpenes (52.4%). Oxygenated fraction consisted mainly of alcohols and their esters, e.g. linalool (14.3%), lavandulol (10%), geraniol (9.3%), 1, 8-cineol (5.9%), dihydrocarveol (3%), α-terpineol (3.4%) and α-terpenyl acetate (1.1%). α-Cymene (4.4%) was the main monoterpene hydrocarbon.

_Melaleuca alternifolia_ Cheel. (Myrtaceae), commonly known as tea tree, is unique to Australia. In India the oil obtained by steam distillation is well known for its activity against bacteria, fungi, yeast and viruses. It is also used for treating minor wounds infections, cuts, strings, acne besides a range of respiratory problems. GLC and GC-MS analysis of tea tree oil resulted in the isolation of 36 components (99.8%) of which 29 were completely characterized (about 92%), six were partially characterized (about 8%), while as one remained unknown (0.1%). The oil was found to be a complex mixture of mainly monoterpenes and sesquiterpenes. The oil was characterized by a high percentage of monoterpene fraction amounting to about 63% that consisted of three oxygenated monoterpenes (53.4%) and four monoterpenic hydrocarbons (9.3%). Terpinen-4-ol (47.7%) was the main monoterpene followed by α-cymene (7.3%), 1,8-cineole (5.3%), and α-thuene (1.2%). The sesquiterpene fraction (14.3%) consisted of seven hydrocarbons (9.7%) and eight oxygenated derivatives (4.6%) with γ-elemene (3.1%) as the main component followed by spathulenol (1.3%), germacrene B (1.2%) and β-caryophyllene (1%). Several isomeric sesquiterpenes and non-terpenic components are being reported for the first time. The main non-terpenic components are butanoic acid (6.3%), formic acid (4.9%), undecone (3.3%) and oleic acid (1.7%).

_Rosa rugosa_ Linn. (Rosaceae) is an erect shrub, up to 2 m. high considered to be a native of Asia Minor and widely grown in gardens throughout India. It has been recorded in India in a wild state are cultivated as ornamentals or for production of rose water and _attar_. The GC and GC-MS analysis of volatile oil of _R. rugosa_ led to isolation of 21 components (99.3%) of which two were partially identified (2.4%). The oil consisted of two monoterpenic hydrocarbons (2.7%) and three oxygenated monoterpenes (29.4%). The
main monoterpane was citronellol (16.8%) followed by pulegone (9.6%) and 1,6-octadien-3-ol (3%). The sesquiterpene fraction consisted of three hydrocarbons (52%) and one oxygenated derivative elemol (2.4%). The main sesquiterpene was γ-elemene (46%) followed by caryophyllene (4.2%) and valencene (1.8%). Five non-terpenic components constitute about 10% of total volatiles.

*Santalinum album* Linn. (Santalaceae) is the source for sandalwood oil. The oil has diuretic, diaphoretic, expectorant, refrigerant, urogenital complaints, depurative, cardiotonic, aphrodisiac, antiseptic, antipyretic, restorative and tonic properties. GLC and GC-MS analysis of the oil resulted in the identification of 12 components comprising 95.5% of total volatiles, out of these one was partially identified while, as one component remained unknown. Quantitatively the oil was characterized by a higher percentage of sesquiterpenes (about 72%) than the monoterpenes (about 13%). Sesquiterpene fraction consisted of trans-β-caryophyllene (14.7%), α-santalol (24.8%), β-santalol (28.4%) and t-nerolidol (3.7%). The monoterpenic fraction consisted of two hydrocarbons and one oxygenated monoterpane. β-Myrcene (8.7%) was the predominant among the monoterpenes followed by cis-verbenol (3.1%) and E-β-ocimene (1.1%). Tridecane (3.8%), formic acid (2.8%) and bis-1, 2-benzene dicarboxylic acid (1.1%) were the non-terpenic components of oil.

*Syzygium aromaticum* Linn. (Myrtaceae), Merrill and Perry, syn. *Caryophyllus aromaticus* Linn.; *Eugenia caryophyllata* Thumbs.; *E. aromatica* Kuntze, commonly known as clove tree is a native of islands of the Malaya Archipelago, especially Moluccas. It is cultivated in Zanzibar and Pemba (Tanzania), Indonesia, Penang, Malagasy and to a lesser extent in the Seychelles, Reunion, Mauritius, India and Sri Lanka. Oil is used as bactericide, preservative, aromatic, stimulant and carminative. It is useful in gastric irritation and dyspepsia. GC and GC-MS analysis of the oil revealed it to be a complex mixture of several components. Total nine components (98.4%) were identified. The oil was characterized by a high percentage of oxygenated monoterpenes (53.2%) dominated by myrtenone (49.1%) and pulegone (4.1%). Oil contained three sesquiterpenes (about 10%), which consisted of β-caryophyllene (8.7%), α-humulene (1.1%) and caryophyllene...
oxide (1%). The major non-terpenic component is eugenol (27.1%) followed by palmitic acid (4.3%) and formic acid (1.6%).

*Vetiveria zizanioides* (Linn.) Nash (Poaceae) *Andropogon muricatus* Retz.; *A. squarrosus* Hook. F., non Linn. f.; *Anatherum zizanioides* (Linn.) Hitchcock et Chase; is one of the two species of vetiver. The oil is reported to be a carminative used in flatulence, colic and obstinate vomiting. Analysis of the oil by GC-MS resulted in identification of 30 components, out of which 25 components; comprising 93% were completely identified while as 5 components (2.1%) were partially identified. Quantitatively the oil was characterized to be a complex mixture of monoterpenes and sesquiterpenes. Monoterpene fraction comprised of one hydrocarbon (0.2%) and one oxygenated monoterpenes (4.5%). The oil was characterized by a high percentage of sesquiterpene fraction dominated by six oxygenated sesquiterpenes (about 50%). Aromadendrene epoxide (20%) was the predominant constituent followed by caryophyllene oxide (19.5%), nerolidol (3%), cedrol (3%) and globulol (2%). Eight sesquiterpene hydrocarbons, comprising 28.3% of total volatiles, consisted of α-gurjunene (7.2%), cadinene (5.1%), Z-β-bisabolene (4%), γ-elemene (3.6) and trans-caryophyllene (2.8%). Nine non-terpenic components consisted of mainly of formic acid (4%), bis-1, 2-benzenedicarboxylic acid (2%), eugenol acetate (1%) and eugenol (0.4%). Oils of *Cinnamomum camphora*, *Cymbopogon citratus*, *Cymbopogon nardus*, *Eucalyptus citriodora* and *Jasminum grandiflorum* inhibited the growth of *S. typhii* completely. Oils of *Jasminum sambac*, *Melaleuca alternifolia*, *Rosa rugosa*, *Syzygium aromaticum* and *Vetiveria zizanioides* inhibited *S. typhii* partially. Incomplete inhibition of *S. typhii* was found in *Lavandula officinalis* and *Santalum album* oils. Complete inhibition of *P. aeruginosa* was found with oils of *Cinnamomum camphora*, *Cymbopogon citratus*, *Cymbopogon nardus*, *Eucalyptus citriodora* and *Jasminum grandiflorum*. Oils of *Jasminum sambac*, *Lavandula officinalis* and *Santalum album* inhibited *P. aeruginosa* partially whereas incomplete inhibition was found in the oils of *Rosa rugosa* and *Vetiveria zizanioides*. Oils of *Cymbopogon citratus*, *Jasminum grandiflorum*, *Jasminum sambac*, *Melaleuca alternifolia* and *Rosa rugosa* showed anti-fungal activity whereas oils of *Cymbopogon nardus* and *Syzygium aromaticum* showed activity up to second dilution also.