



## Essential oils as Therapeutics

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### Abstract

Essential oils are the volatile secondary plant metabolites which mainly consist of terpenoids and benzenoids. Research in the later half of 20th century has revealed that many curative properties attributed to various plants in indigenous medicine are also present in their essential oils. These oils exert a number of general effects from the pharmacological viewpoint. When applied locally, the essential oils mix readily with skin oils, allowing these to attack the infective agents quickly and actively. Therapeutic properties of various essential oils based on folklore, experiences and claims of aromatherapists and scientific studies have been summarised in this review. *In vitro* studies conducted by the author on antimicrobial and anthelmintic properties of some essential oils have also been discussed.

**Keywords:** Essential oils, Therapeutics, Aromatherapy, Antimicrobial, Anthelmintic.

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Kingdom. British nurses are insured by the Royal College of Nurses to use essential oils both topically and inhalation for improved patient care. Lavender oil with its mild sedative powers is being tested as a drug replacement to treat older patients suffering insomnia, anxiety and depression and to make terminal care patients more comfortable. In New York hospitals vanilla oil is released under patient's noses to help them relax before an MRI scan. Italian research has shown it to relieve anxiety and fear.

### Modes of essential oil usage

Inhalation for respiratory tract infections and physiological effect, topical application for burns, skin and muscular problems, compress for swellings and ingestion for intestinal complaints are some suitable modes. Taking a bath in water with few drops of some essential oils is also very useful. Massage with 1-3% (few drops) of essential oils in cold pressed carrier oils (vegetable oils) is another mode of application of essential oils. Except lavender and tea tree oils which are very mild, the essential oil should be used after dilution in carrier oils or inhaled directly from a cotton wool or floating on the top of hot water. As essential oils have specific effects they are also used in various combinations working in harmony having synergistic effect on the body.

### Introduction

Herbal medicines are the gift of 'Mother Nature' to its children, the mankind. The fragrance of myriad flowers and herbs enchants man, elevates the mood and leads to feeling good. Essential oils, the secondary plant metabolites, and the most sublime extractive of plants, found their way from herbal medicine. Inhaling the aromas for therapeutic purposes and then use of essential oils in whatever way they are useful in therapy became the basis of aromatherapy. The recorded history of ancient civilizations indicate the use of aromatic plants like lavender, cedar and cypress for curing ailments, offerings to deities and

anointments. In 1928, a French chemist Dr. Rene Gattefosse, while working on essential oils badly burned his hand in laboratory and desperately plunged it into the nearest vat containing lavender oil. He was astonished to see how quickly the pain ceased having no blisters and the skin healed quickly than normal without forming a scar. Later on he studied the therapeutic benefits of essential oils and coined the word "Aromatherapie" (the anglicized form is Aromatherapy) and published first treatise on aromatherapy in 1937<sup>1</sup>. Thus, Aromatherapy is defined as the use of essential oils for therapeutic purposes.

Aromatherapy has been accepted as a part of nursing care in the United



**Therapeutics properties of some essential oils**

Therapeutic properties of various essential oils based on folklore, experiences and claims of aromatherapists and scientific studies have been summarised in this review<sup>2-20</sup>.



Lavender (Lavandula officinalis)

**Lavender, *Lavandula angustifolia* Mill. syn. *L. officinalis* Chaix (*Lamiaceae*) oil:** For centuries

lavender oil obtained from the flowering tips of the evergreen shrub, has been used in perfumes and aromatherapy. Lavender oil is rich in linalyl acetate, geraniol and cineole. It is a natural antibiotic, antiseptic, anti-depressant and sedative. It is often used to treat scalds, minor burns, cuts, grazes, inflammation, eczema, dermatitis, headaches, insomnia, acne, dandruff, boils, rheumatism<sup>4</sup>, arthritis, leucorrhoea, dysmenorrhoea and stretch marks<sup>6, 8, 9</sup>. Lavender reduces anxiety, stress and tension and therefore it is used for calming, soothing and relaxation<sup>10</sup>. It is used by way of vapours from oil burners, massage, bath water and inhaler. A few

drops in a bath of warm water before bed time will relieve anxiety and alleviate insomnia while having the bath with cool water instead, will make one feel refreshed and energized.

**Tea tree, *Melaleuca alternifolia* Cheel (*Myrtaceae*) oil :** It was used as a disinfectant by Australian soldiers during first world war. It was a part of the first aid kits of Australian soldiers for bites and infections during the second world war. Commercial houses claim it to be the greatest natural antiseptic of the world. Aromatherapy claims it to be effective in clearing colds and sour throat if its vapours are inhaled through



Basil (*Ocimum basilicum*)



Rose (*Rosa damascena*)



Sandal tree (*Santalum album*)



Tea tree (*Melaleuca alternifolia*)



Eucalyptus (*Eucalyptus globulus*)



Jasmine (*Jasminum officinale*)



steam. Mouth sores and gingivitis can be checked by the mouth wash made by putting a few drops of the tea tree oil into a cup of warm water. It is ascribed with anti-inflammatory properties. The oil acts as an antiseptic for treating boils, rashes, cuts and scrapes as well as insects bites, stings and carbuncles. It can be applied directly to the skin. The oil promotes healing of minor wounds and minimise any future scarring. It has been shown effective against Methicillin Resistant *Staphylococcus aureus* (MRSA) bacteria<sup>12</sup>. Tea tree oil helps in regulating Sebum production. A gel containing 5% tea tree oil has been shown as effective in the treatment of acne as a lotion with 5% benzoyl peroxide with far less scaling and itching<sup>13</sup>. A solution containing 0.5% tea tree oil could offer protection against *Pityrosporum ovale*, a common dandruff causing fungus and head lice. It could check fungal infection under toenails and bromhidrosis (smelly foot). The oil has been shown effective against *Candida albicans* and *Trichomonas vaginalis*, two of the organisms that cause vaginal infections<sup>14</sup>. Tampons moistened with a few drops of the oil or its douches for a week are recommended for this purpose. The oil has been found effective in chronic cystitis. Cytotoxicity evaluation of the oil using human cell lines supports the use of tea tree oil in topical applications but not for ingestion purposes<sup>15</sup>. Biological activity of tea tree oil has been recently reviewed<sup>16</sup>.

**Sandalwood, *Santalum album* Linn. (*Santalaceae*) oil:** Sandalwood oil has been used in Indian Ayurvedic system for centuries. It is renowned for its sublime, aphrodisiac, diuretic and urinary antiseptic properties.

The oil is extracted by steam or hydrodistillation from roots and wood. India is the biggest exporter of this oil. It supports the lymphatic system, nervous and cardiovascular system and relieves the symptoms of sciatica and lumbago. It has been found to help remove negative programming from the cells and increases oxygen around the pituitary and pineal glands<sup>9</sup>. Sandalwood oil removes depression, anxiety, nervousness, stress and insomnia. It helps to soften dry, mature or wrinkled skin. It may also reduce irritation from hives and other rashes. Topical application helps remove acne and herpes.  $\alpha$ - and  $\beta$ -Santolol and santenone are main constituents of the sandalwood oil. Sandalwood oil has been shown to have antiviral activity against *Herpes simplex* 1 and 2. The essential oil appeared to interfere with the virus's ability to replicate<sup>17</sup>.

**Eucalyptus, *Eucalyptus globulus* Labill. (*Myrtaceae*) oil:** The essential oil from the leaves is rich in cineole and affects the respiratory system. It is antibacterial, antifungal, antiviral, anticatarrhal, mucolytic, expectorant and antidepressant. Inhalation of the oil is effective in asthma, bronchitis, colds, flu, catarrh and sinus infections<sup>8</sup>. For this sprinkle a few drops of the oil on a damp cloth and hold it close to the nose and exhale through the mouth for about a minute. It soothes dry coughs. Topical application of the dilute oil is effective in burns, warts, insect bites, lice, herpes and foot odour<sup>9</sup>. It combats skin infections such as boils and pimples. Mixed with carrier oil it can be used as a liniment to reduce swellings and muscle aches and pains. It promotes alertness, clears the mind. Eucalyptus oil has been used

successfully from as early as 1789.

**Jasmine, *Jasminum officinale* Linn. (*Oleaceae*) oil:** Jasmine was introduced in Europe from India and Persia. It is best known for its use in perfumes. Benzyl acetate, linalyl acetate, geraniol, linalool and jasmone are its main constituents. It is beneficial for the skin reducing problems such as dry, irritated or sensitive skin, muscle spasms, sprains, laryngitis, dysmenorrhea, labour pain, frigidity, depression, and nervous exhaustion. It induces relaxation<sup>9</sup>.

**Rose, *Rosa × damascena* Mill. (*Rosaceae*) oil:** Rose oil has a long history of medicinal and cosmetic use. It is perhaps the most precious of all essential oils obtained by steam distillation, enfleurage or solvent extraction from petals. Its invigorating fragrance is almost intoxicating and aphrodisiac like. It enhances the frequency of every cell, bringing balance and harmony to the body. It is anti-haemorrhaging, anti-infectious and prevents scarring. It may help in chronic bronchitis, conjunctivitis, asthma, depression, emotional shock, stress<sup>18</sup>, tension, aged and dry skin, frigidity, impotence, wrinkles, thrush and gingivitis<sup>6,9</sup>.

Rose oil passeries are being tried as a contraceptive. It is stimulating and elevating to the mind, creating a sense of well being. It is a muscle relaxant. It tones the capillaries, improves blood circulation to the skin surface and revitalises it, thus refreshing a person's looks and increases confidence.

**Basil, *Ocimum basilicum* Linn. (*Lamiaceae*) oil:** Basil is native of India where it is regarded as a sacred



herb and used traditionally in Indian system of medicine. Now it is grown in Mediterranean and European countries also. The essential oil from the leaves and inflorescence, extracted by steam distillation, is rich in methyl chavicol and linalool. It has been found to be beneficial for alleviating mental fatigue, spasms, rhinitis, and as a first aid treatment for wasp stings and snake bites. It may also help when there is a loss of smell due to chronic nasal catarrh<sup>9</sup>. It can be used as a mouthwash for relieving toothache. It has antibacterial and expectorant qualities apart from being useful in the treatment of ringworm and some skin diseases.

**Coriander, *Coriandrum sativum* Linn. (Apiaceae) oil:** The seed oil has anti-inflammatory and sedative properties<sup>9</sup>. A communication from Cairo University indicates that the oil lowers glucose levels by normalizing insulin levels and supporting pancreas function. The main constituents of the oil are linalyl acetate, carvacrol and linalool oxide.

**Clove, *Syzygium aromaticum* (Linn.) Merrill & Perry (Myrtaceae) oil:** The oil of clove bud is used as an antiseptic and anesthetic in mouth infections. It is used in European hospitals to dental infections. It is also used in thyroid dysfunction<sup>11, 15</sup>. Eugenol is the main constituent of the oil.

**Chamomile, *Matricaria recutita* Linn. (Asteraceae) oil:** Oil from the flowers has chamazulene which gives the oil its classical anti-inflammatory properties which have been shown comparable to hydrocortisone<sup>19</sup>. It is renowned for its calming ability and skin care. It may help in leg cramps, muscle tension, insomnia and allergies. It

stimulates appetite and combats diarrhoea. It helps heal acne and reduces other types of skin inflammation.

**Roman chamomile, *Chamaemelum nobile* (Linn.) All. syn. *Anthemis nobilis* Linn. (Asteraceae) oil:** The oil may also be used as an anti-inflammatory but it is used more often in aromatherapy as an antispasmodic and sedative.

**Peppermint, *Mentha piperita* Linn. (Lamiaceae) oil:** The mentha oil helps to reduce fevers, nausea, vomiting and aids in respiratory function. It helps in headaches, migraines, motion sickness and sinusitis<sup>6, 8</sup>. It helps cooling the body during hot summer days. Menthol, menthone and cineole are the main constituents of the oil.

**Petitgrain, *Citrus aurantium* Linn. (Rutaceae) oil:** The oil is obtained from the leaves and twigs of the bitter orange tree. It has a gentle sedative action on inhalation and is useful in cases of insomnia and fatigue. It re-establishes nerve equilibrium. Terpene alcohols and linalyl acetate are the main constituents of the oil. Lemon, orange and other citrus oils improve mood and increase alertness.

**Rosemary, *Rosmarinus officinalis* Linn. (Lamiaceae) oil:** The oil is extracted by steam distillation of leaves and flowering tops. The oil can be used in arthritic pain<sup>6, 8</sup>, asthma, bronchitis, catarrh, memory loss, mental fatigue and muscular pain. It may be beneficial for skin conditions and dandruff and may help fight candida and support immune system. It is a carminative also.  $\alpha$ -Pinene, camphene, borneol, bornyl acetate, camphor and cineole are the main constituents of the oil. Rosemary oil and

its main constituent bicyclic ether 1, 8-cineole act as an activating, refreshing remedy against exhaustion. The locomotor activity of the test animals increased significantly by inhalation of this ether or this oil<sup>2</sup>. Pregnant ladies, epileptic and hypertensive persons should avoid its use.

**Juniper berry, *Juniperus communis* Linn. (Cupressaceae) oil:** Juniper has long been known for its antiseptic and diuretic properties. The essential oil is obtained by steam distillation from the berries. The oil may work as a detoxifier, astringent and cleanser, reducing dermatitis, oozing eczema and acne. It has also been used to promote better nerve and kidney function<sup>8</sup>. It helps to reduce cellulite.  $\alpha$ -Pinene, sabinene and juniperene are its important constituents.

**Sweet Marjoram, *Origanum majorana* Linn. (Lamiaceae) oil:** It is calming to the respiratory system and assists in relieving spasms and migraine headaches. It increases peristaltic movements of intestine. It is soothing to nerves and works as diuretic<sup>8</sup>. Sabinene,  $\alpha$ -terpineol, terpinene-4-ol, geraniol and linalool are the main constituents of the oil.

**Thyme, *Thymus vulgaris* Linn. (Lamiaceae) oil:** It has a spasmolytic and antiseptic effect and it has been successfully administered precutaneously to babies suffering from pertussis. Thymol, carvacrol and camphene are its main constituents. Valnet<sup>20</sup> found it to destroy anthrax and bacillus and a stronger antiseptic than phenol. Camphor, borneol, thymol and menthol are said to possess stronger bactericidal properties than those of phenol. Borneol was used as a prophylactic to plague in middle ages. The active bactericidal constituent of the



essential oil of garlic, allicin, retains its effect even in dilution of 1:1,25,00. The oil of wintergreen mainly containing methyl salicylate is used topically in the treatment of rheumatism.

Essential oils of Juniper berries and dwarf pine needles acted in the same way against exhaustion. Contingent negative variation (CNV) (it is a slow upward shift in brain waves recorded by the electro encephalogram EEG) studies have showed that jasmine oil brought about an effect similar to the administration of caffeine, i.e. an increase CNV after inhalation where as lavender oil caused CNV to decrease, similar to the administration of tranquilizers, thus leading to a sedation<sup>3</sup>.

### Antimicrobial and anthelmintic activities of some essential oil bearing plants

**Anacardium occidentale Linn.** (*Anacardiaceae*): On neuropharmacological studies the oil has been found to be CNS depressant on the basis of its activity on behaviour, sodium pentobarbitone induced hypnosis, rota rod performance, conditioned avoidance response and pain threshold of albino rats<sup>21</sup>. The oil has shown strong antibacterial activity against *Pseudomonas mangiferae*, *P. aeruginosa*, *Salmonella* sp., *Bacillus mycorides*, *Vibrio cholerae* and *Xanthomonas campestris*<sup>22</sup>.

**Artemisia pallens Wall. ex DC.** (*Asteraceae*): The essential oil has strong antimicrobial activity against *Escherichia coli*, *Vibrio cholerae*, *Bacillus subtilis*, *Staphylococcus*

*aureus*, *Salmonella typhi*, *Aspergillus* sp., *Chrysosporium indicum*, *Trichophyton mentagrophytes*<sup>23</sup>. The oil has exhibited good anthelmintic activity against *Pheritma posthuma* (earthworm), *Taenia solium* (tape worms) and *Ascaris lumbricoides* (round worms)<sup>24</sup>.

**Capillipedium foetidum** (*Poaceae*): The oil has shown strong antibacterial and antifungal efficacy<sup>25</sup>.

**Curcuma longa Linn.** (*Zingiberaceae*): The essential oil is effective against the conditions caused by *Aspergillus* sp., *Bacillus subtilis*, *Corynebacterium diphtheriae*, *Staphylococcus aureus*, *Salmonella typhi* and *Escherichia coli*<sup>26</sup>.

**Elettaria cardamomum Maton** (*Zingiberaceae*): The essential oil contains: cineole, 30.7; limonene, 14.3; and terpenyl acetate, 28.1%. *Bacillus subtilis*, *Corynebacterium diphtheriae*, *Staphylococcus aureus*, *Salmonella typhi*, *Shigella* sp., *Escherichia coli*, *Aspergillus niger*, *A. fumigatus*, *Rhizopus oryzae*, *Fusarium psidi* and *Curvularia lunata* were found susceptible to the oil<sup>27</sup>.

**Eupatorium triplinerve Vahl** (*Asteraceae*): The oil from the flowers is rich in thymohydroquinone dimethyl ether (50.36%). It has shown good *in vitro* efficacy against *Bacillus subtilis*, *Diplococcus pneumoniae*, *Vibrio cholerae* and helminths, *Ascaris lumbricoides* and *Taenia solium*<sup>28</sup>.

**Feronia limonia (Linn.) Swingle** syn. *F. elephantum* Correa (*Rutaceae*): The essential oil is very rich in methyl chavicol 68.3%, *Escherichia*

*coli*, *Pseudomonas aeruginosa*, *Shigella shiga*, *Staphylococcus* sp., *Proteus vulgaris*, *Trichoderma viride* and *Trichophyton rubrum*, have been found susceptible for the oil<sup>29</sup>.

**Myrtus communis Linn.** (*Myrtaceae*): The oil from the leaves of *Myrtus communis* var. *microphylla* caused strong inhibition to the growth of *Trichoderma viride*, *Candida albicans*, *C. utilis* and *Aspergillus niger* which cause dermatitis<sup>30</sup>.

**Pavonia odorata Willd.** (*Malvaceae*): The oil has shown strong anthelmintic activity against tapeworms and roundworms<sup>24</sup>. *Staphylococcus aureus*, *Diplococcus pneumoniae*, *Trichophyton mentagrophytes*, *Chrysosporium indicum* and *Botrydiploia* sp. were also reported susceptible to the oil<sup>31</sup>.

**Piper betle Linn. cv. 'Sagar bangla'** (*Piperaceae*): Cultivar 'Sagar bangla' is highly active against the Keratinophilic fungi and bacterial organisms, *Bacillus subtilis*, *B. pumulus*, *Staphylococcus aureus*, *Salmonella typhi* and *Vibrio cholerae*. The essential oil was also found to be more effective against tapeworms (*Taenia solium*) and hookworms (*Bunostomum trionocephalum*) than the synthetic anthelmintics, Piperazine phosphate and Hexyl resorcinol<sup>32</sup>.

**Zingiber officinale Rosc.** (*Zingiberaceae*): The oil has strong insect repellent activity against, *Periplaneta americana* and *Bruchus pisorum*<sup>33</sup>.

Essential oils isolates, cumaldehyde (**Cuminum cyminum Linn.**), 1,8-cineole [**Luvunga scandens**



(Roxb.) Buch.-Ham. ex Wight], against many pathogenic fungal in various problems and diseases is given caryophyllene and eugenol (*Ocimum* organisms<sup>34</sup>. in Table 1<sup>9</sup>. *sanctum* Linn.) possess strong activity A summary of essential oils used

**Table 1 : Summary of essential oils used in various diseases/problems**

S.No.	Diseases/other problems	Essential oils
1.	Abcesses	Lavender, Tea tree.
2.	Accumulation of toxins	Birch, Carrot seed, Juniper.
3.	Acne	Bergamot, Chamomile, Geranium, Lavender, Palmarosa, Patchouli, Sandalwood, Tea tree.
4.	Amenorrhoea (missing or scanty period)	Basil, Clary sage, Marjoram.
5.	Anxiety	Lavender, Chamomile, Tea tree, Geranium.
6.	Arthritis	Birch, Black pepper, Chamomile, Eucalyptus, Ginger, Juniper, Rosemary.
7.	Asthma	Clary sage, Cypress, Frankincense, Lavender, Marjoram.
8.	Boils	Bergamot, Chamomile, Lavender.
9.	Bronchial infections (including colds, flu and bronchitis)	Basil, Benzoin, Cajeput, Cedarwood, Eucalyptus, Frankincense, Ginger, Lavender, Marjoram, Myrtle, Peppermint, Pine needle, Sandalwood, Tea tree, Thyme.
10.	Bruises, Burns	Fennel, Marjoram.
11.	Cold sores	Bergamot, Eucalyptus, Tea tree.
12.	Constipation	Rose, Fennel.
13.	Cystitis	Bergamot, Lavender, Sandalwood.
14.	Dandruff	Lavender, Eucalyptus, Tea tree.
15.	Depression	Basil, Bergamot, Lavender, Lime, Sandalwood.
16.	Dermatitis	Birch, Chamomile, Lavender, Palmarosa, Basil.
17.	Eczema	Bergamot, Birch, Chamomile, Lavender, Melissa, Patchouli.
18.	Fevers	Eucalyptus, Lemongrass.
19.	Griping pains	Cardamom seeds, Peppermint.
20.	Gout	Benzoin, Carrot seed, Juniper, Lemon, Rosemary.
21.	Insect bites and Stings	Basil, Chamomile, Lavender, Tea tree.
22.	Insect repellent	Lemongrass, Citronella, Lavender.
23.	Insomnia	Chamomile, Lavender, Marjoram.

S.No.	Disease/other problems	Essential oils
24.	High BP	Lavender, Ylang Ylang.
25.	Leucorrhoea (white vaginal discharge)	Bergamot, Lavender, Myrrh.
26.	Menopause (hot flushes, mood swings)	Cypress, Chamomile, Fennel.
27.	Migraine	Lavender.
28.	Muscular aches and Pains	Basil, Black pepper, Chamomile, Eucalyptus, Ginger, Grapefruit, Lavender, Marjoram, Rosemary.
29.	Nausea	Cardamom seed, Chamomile.
30.	Pruritis	Bergamot, Myrrh, Tea tree.
31.	Psoriasis	Bergamot, Birch.
32.	Pyorrhoea	Fennel.
33.	Haemorrhoids (Piles)	Cypress, Parsley seed.
34.	Sprains and Strains	Chamomile, Lavender.
35.	Herpes	Tea tree, Sandalwood.
36.	Stretch marks	Mandarin, Lavender.
37.	Rheumatism	Benzoin, Birch, Chamomile, Eucalyptus, Ginger, Juniper, Lavender, Marjoram, Rosemary.
38.	Scars	Frankincense, Petitgrain, Lavender.
39.	Vaginitis	Tea tree.
40.	Verrucas, Corns and Warts	Lemon, Tea tree.
41.	Vertigo	Lavender, Peppermint.
42.	Worms	Chenopodium.

Practical guidelines to use essential oils in some common health problems are:

- **Abdominal pain:** Add 2 drops of bitter orange and 2 drops caraway to 2 cups of hot water and inhale the fragrant vapours. Alternatively add 2 drops of peppermint oil, 2 drops of bitter orange, and 2 drops of caraway oil in one teaspoon of a cold pressed carrier oil and smooth this gently over the painful area of abdomen in a clockwise circulatory motion for few minutes.
- **Cough:** Mix 3 drops of cedar wood, 2 drops peppermint oil and 1 drop of cajuput oil with 2 teaspoons of olive oil and massage on to throat and chest.
- **Earache:** Add 4 drops of lavender, cajuput or chamomile oil in half a litre of steaming hot water and inhale the steam for 10 minutes.
- **Headache** (from cold or allergic rhinitis): Pour 2 drops each of sweet marjoram, lavender and peppermint oils on a tissue and inhale deeply 3 times.
- **Nose bleeding:** Cypress oil helps stop blood loss. Put a few drops on a cotton wool ball and hold under the nose to stop bleeding.



## Conclusion

As such there is reasonable evidence that aromatherapy has scientific basis and is gaining acceptance under holistic system of healing. European physicians and aromatherapists now frequently prescribe essential oils for a variety of complaints including colds and stuffy nose, sinusitis, insomnia, migraine, muscle aches and pains and digestive problems.

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## Antibacterial properties and potential applications of essential oils in foods

Recently Sara Burt at Department of Public Health and Food Safety, Faculty of Veterinary Medicine, University of Utrecht, The Netherlands has published a review entitled, 'Essential oils: their antibacterial properties and potential applications in foods' which conclude that *in vitro* studies have demonstrated antibacterial activity of essential oils (EOs) against *Listeria monocytogenes*, *Salmonella typhimurium*, *Escherichia coli* O157:H7, *Shigella dysenteria*, *Bacillus cereus* and *Staphylococcus aureus* at levels between 0.2 and 10 µl/ml. Gram negative

organisms are slightly less susceptible than Gram positive bacteria. A number of EO components have been identified as effective antibacterials, e.g. carvacrol, thymol, eugenol, perillaldehyde, cinnamaldehyde and cinnamic acid, having minimum inhibitory concentrations (MICs) of 0.05-5 µl/ml *in vitro*. A higher concentration is needed to achieve the same effect in foods. Studies with fresh meat, meat products, fish, milk, dairy products, vegetables, fruit and cooked rice have shown that the concentration needed to achieve a significant antibacterial effect is around

0.5-20 µl/g in foods and about 0.1-10 µl/ml in solutions for washing fruit and vegetables. Physical conditions that improve the action of EOs are low pH, low temperature and low oxygen levels. Synergism has been observed between carvacrol and its precursor *p*-cymene and between cinnamaldehyde and eugenol. Synergy between EO components and mild preservation methods has also been observed. Some undesirable organoleptic effects can be limited by careful selection of EOs according to the type of food [Sara Burt, *Int J Food Microbiol*, 2004, **94**(3), 223-253].