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REVIEW ARTICLE

Biological Activities of Lavender Essential Oil

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Essential oils distilled from members of the genus *Lavandula* have been used both cosmetically and therapeutically for centuries with the most commonly used species being *L. angustifolia, L. latifolia, L. stoechas* and *L. x intermedia*. Although there is considerable anecdotal information about the biological activity of these oils much of this has not been substantiated by scientific or clinical evidence. Among the claims made for lavender oil are that is it antibacterial, antifungal, carminative (smooth muscle relaxing), sedative, antidepressive and effective for burns and insect bites. In this review we detail the current state of knowledge about the effect of lavender oils on psychological and physiological parameters and its use as an antimicrobial agent. Although the data are still inconclusive and often controversial, there does seem to be both scientific and clinical data that support the traditional uses of lavender. However, methodological and oil identification problems have severely hampered the evaluation of the therapeutic significance of much of the research on *Lavandula* spp. These issues need to be resolved before we have a true picture of the biological activities of lavender essential oil. Copyright © 2002 John Wiley & Sons, Ltd.

Keywords: lavender; Lavandula; antimicrobial; aromatherapy.

INTRODUCTION

Most of us have grown up with the scent of lavender in our homes and this essential oil continues to be as popular today as it has been down the centuries past. Documented evidence for the use of lavender as a therapeutic agent can be traced back to the ancient Romans and Greeks and the continuing popularity and commercial value of lavender was recently confirmed when it was named ‘Herb of the Year 1999’ by the Herb Growing and Marketing Network in the United States of America (Evelegh, 1996; Anonymous, 1999). Lavenders (*Lavandula* spp.) belong to the family Labiatae (Lamiacae) and have been used either dried or as an essential oil for centuries for a variety of therapeutic and cosmetic purposes. Lavender essential oil is produced, usually by steam distillation, from both the flower heads and foliage, but the chemical composition differs greatly, with the sweeter and most aromatic oil being derived from the flowers (McGimpsey and Porter, 1999). The oil is traditionally believed to be antibacterial, antifungal, carminative (smooth muscle relaxing), sedative, antidepressive and effective for burns and insect bites (Grieve 1931; Gattefosse, 1937). Today, the pure oil is most often used in aromatherapy or incorporated into soaps and other products as a pleasant fragrance or as an antimicrobial agent. Yet despite its popularity, and the long tradition of use, it is only recently that science-based investigations into the biological activity of the various *Lavandula* species have been undertaken to any great extent. In this paper we review current research investigating the biological activities of lavender oil and highlight areas that require further investigation. As confusion over the common names for lavender species occurs throughout both the lay and the scientific press botanical names are used, where known, in this review.

Lavenders fall into four main categories: *Lavandula latifolia*, a Mediterranean grass-like lavender; *Lavandula angustifolia*, a stockier plant with a fuller flower, commonly known as English lavender (formerly known as *L. vera* or *L. officinalis)*; *Lavandula stoechas*, which has butterfly-like bracts on top of the flowers and is sometimes known as French lavender; and *Lavandula x intermedia*, which is a sterile cross between *L. latifolia* and *L. angustifolia*. The various lavenders have similar ethnobotanical properties and major chemical constituents, however, there are some differences in the reported therapeutic uses for different species. For example most lavenders are believed to have carminative actions but *L. stoechas* is traditionally used for headache, *L. latifolia* as an abortifacient and *L. angustifolia* as a diuretic (Agricultural Research Service, 2000). Many of the activities attributed to lavender oils, however, have not been substantiated in the scientific literature. For example, although lavender is often listed as a substance to be avoided in pregnancy (Fetrow and Avila, 1999; Langer, 2000) there is no evidence to support this claim which seems to be based on the belief that lavender oil is an emmenagogue and hence able to promote and regulate menstruation. It would seem logical that if a substance has the capacity to bring on menses that, should fertilization have occurred then the embryo would be lost and the substance would be, by default, an abortifacient. However, there is no scientific evidence to suggest that lavender is in fact an emmenagogue, nor is

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there any consensus as to which lavender species has these properties or whether these properties refer to ingested or cutaneously absorbed lavender.

CHEMICAL COMPOSITION OF LAVENDER ESSENTIAL OILS

Essential oils are complex mixtures of many different aromatic compounds. The oil composition is determined mainly by the genetic make-up of each cultivar, although it can also be influenced by the distillation process (McGimpsey and Porter, 1999). There are a number of methods used for the analysis of oils from the *Lavandula spp.* including standard analytic techniques of gas chromatography with mass spectrometry (GC/MS) or infra-red spectroscopy (GC/IRFT). As a consequence the oil profile of lavenders used commercially are well known (Ristorcelli *et al.*, 1998) and International Standard specifications (ISO) have been published for some, but not all, lavenders (McGimpsey and Porter, 1999). The main constituents of lavender oil are linalool, linalyl acetate, 1,8-cineole, β-ocimene (usually both *cis*- and *trans*-), terpinen-4-ol and camphor. Each of these constituents can vary significantly in oils derived from different cultivars with the relative levels of each being the main determinant of market value, application and aroma.

The traditional analysis of *Lavandula* oils, however, has mainly focused on analysis of the oil derived from flower heads. More recently, focus has turned towards analysis of the flower 'aroma', defined as the analysis of the head space volatile components rather than the whole liquid oil. Several researchers have produced aroma profiles for the various lavenders, which can vary significantly from the whole oil profile (Weisenfeld, 1999; An *et al.*, 2001). Aroma analysis of those plants with typical scents has demonstrated that oils derived from *L. stoechas* and *L. lanata* have high camphor levels while *L. angustifolia, L. dentata* and *L. pinnata* are low ($<2\%$) in camphor. These low camphor plants tend also to have higher levels of terpenes (e.g. β-phellandrene) and sesquiterpenes (e.g. caryophyllene). This is not unexpected given the profile of the essential oil and the traditional use of these plants. For example, *L. angustifolia* is used in the perfumery and cosmetic industries while the high camphor plants are used as insect repellents and for other non-perfumery uses. Further comparison of the oil and aroma profiles (volatile component) has shown significant differences between the two profiles particularly with respect to the level of linalool, linalyl acetate (both higher in oil) and various sesquiterpenes (higher in the volatiles) (Weisenfeld, 1999). This is an especially important point when considering the bioactivity of these oils in aromatherapy situations, where the 'aroma' or volatiles are likely to play a significant role.

NEUROLOGICAL EFFECTS OF LAVENDER

Aromatherapy is thought to be therapeutically effective due to both the psychological effect of the odour and the physiological effects of the inhaled volatile compounds, where the latter effects are believed to act via the limbic system, particularly the amygdala and hippocampus. While the exact cellular mechanism of action is unknown one author has suggested that lavender (based on studies of *L. angustifolia*) may have a similar action to the benzodiazepines and to enhance the effects of gamma-aminobutyric acid in the amygdala (Tisserand, 1988). Others have found that linalool inhibits acetylcholine release and alters ion channel function at the neuromuscular junction (Re *et al.*, 2000). Linalool and linalyl acetate are rapidly absorbed through the skin after topical application with massage, reaching peak plasma levels after approximately 19 min (Jager *et al.*, 1992) and are thought to be able to cause central nervous system depression. Linalyl acetate has narcotic actions and linalool acts as a sedative (Tisserand and Balacs, 1999; Re *et al.*, 2000). These calming actions of lavender may be the origin of the traditional use of a lavender herb pillow to help induce sleep. The high camphor content in some lavenders (e.g. *L. stoechas*), however, is thought to precipitate convulsions when used at high concentrations (Tisserand and Balacs, 1999).

A number of studies have also investigated the effect of either lavender, or its major constituent linalool, on brain activity or specific receptor populations (Yamada *et al.*, 1994; Elisabetsky *et al.*, 1995; Elisabetsky *et al.*, 1999). However, the relevance of these studies is limited as they were performed in laboratory rodents and do not reflect the normal doses or exposure routes to lavender essential oil in humans.

Lavender oil today is used predominantly in aromatherapy or massage, and many benefits are claimed for use in this way. In 1993 the General Hospital, Tullamore (Ireland) trialed the use of a mix of essential oils (basil, juniper, lavender and sweet marjoram) in improving sleep in older patients (Graham, 1995). The aim was to reduce sleep disturbance and hence to improve the overall well-being. Following a combination of oil vaporization, with or without a 5 min hand-massage, over a 2 week period there was a significant increase in the number of patients reporting having had a good nights' sleep and a reduction in those requiring additional night sedation. Dunn *et al.*, (1995) demonstrated anxiety alleviation in patients in intensive care units where each consenting subject in the intensive care unit received at least one session of lavender (1% *L. angustifolia*) aromatherapy treatment. Each patient had a 24 h break between treatments and a number of physical, behavioural and psychological measures were recorded. No significant differences in the indicators of physiological stress (blood pressure, heart rate and rhythm, respiratory rate) or behavioural responses (e.g. motor activity, facial expressions or Glasgow coma rating for unconscious patients) were observed between individuals treated with massage, aromatherapy or rest. There was a significant improvement in the anxiety levels in the aromatherapy group during the first session of treatment. Interestingly although there was no statistically significant improvement during the second or third session this appears to be due to an increased effectiveness of the other therapies rather than a loss of effectiveness of the aromatherapy. Long-stay neurology in-patients, in a pilot study by Walsh and Wilson (1999), also showed increased mood scores and reduced psychological distress following aromatherapy (tea tree, rosemary and *L. angustifolia* oils). These studies suggest that lavender aromatherapy can improve patients' experiences in intensive care with no detrimental physical or behavioural outcomes.

Several authors have also noted an association between lavender odour and positive emotional states. Alaoui-Ismaili *et al.* (1997) found that the odour of lavender oil is rated as a pleasant one and is correlated with changes in the autonomic nervous system. Subsequently Tysoe (2000), while investigating the effects of oil burners and lavender oil on those working in or visiting an extended care ward, found that 88% of respondents thought that lavender oil had a positive effect on the ward and suggest that lavender oil vapour may help combat the unpleasant odours that can sometimes be present in hospitals. Interestingly, Millot and Brand (2001) found that lavender odour increased the pitch of both male and female voices, with greater increases in female voices. Vocal changes can be used to gauge emotion with increases in pitch associated with socio-positive emotions (e.g. happiness and joy). Diego *et al.* (1998) found that individuals receiving lavender oil (10%) odour for 3 min were significantly more relaxed, had decreased anxiety scores, better moods and showed increased alpha power in their EEGs (an indication of increased drowsiness). Masago *et al.* (2000) have also found that inhalation of lavender produces EEG patterns characteristic of subjects 'feeling comfortable'.

Interestingly Diego *et al.* (1998) also found that lavender oil aromatherapy increased the speed and accuracy of mathematical calculations—perhaps the origin of the sixteenth century belief that lavender skullcaps could enhance intelligence! Further support for these findings comes from a study by Degel and Koster (1999). Subjects performed a number of tests in rooms which were only weakly scented with an essential oil. Although the subjects did not identify that the room was scented, those in the lavender-scented rooms had superior performances to those in the jasmine or unscented rooms. In addition, a study in NSW, Australia found that when patients in a dementia day-care facility recieved a 10 to 15 min hand-massage with a mix of three oils, including lavender, they had a significant improvement in all areas measured. These included the patients' feelings of well-being, increased alertness, decreased aggression and anxiety and improved sleeping patterns (Kilstoff and Chenoweth, 1998). A crossover study by Lindsay *et al.* (1997), however, implied that lavender oil used in hand massage did not seem to improve concentration in subjects with profound learning disabilities. This study was, however, limited by small sample size (8 participants), and the lack of a control group. From these data it appears that lavender oil used alone, or in combination with other oils, is of considerable benefit in a number of situations and is safe, effective and easily administered to both conscious and unconscious patients. Further it is likely that a room scented with lavender oil will be perceived to be a pleasant environment and this may be particularly beneficial in some health care settings. The only caveat to this statement is that several difficulties arise in the interpretation of these results as often combinations of oils and therapies are used, details of lavender oil species and volumes used are often absent, massage effects are often not separated from those as a result of odour alone and the sample sizes are generally very small. Nevertheless, it does appear that lavender oil, particularly when combined with massage has the potential to be of significant benefit to patients, visitors and workers in many health care settings.

Aromatherapy has also been advocated as useful in the treatment of chronic or intractable pain (Buckle, 1999) with oils high in 1,8-cineole, for example *L. latifolia*, appearing to be particularly good analgesics. Buckle (1999) reports several studies that demonstrate that aromatherapy, with or without massage, can reduce the perception of pain and the need for conventional analgesics in both adults and children. However, almost all studies cited by this author were small, uncontrolled or lacking in the normal scientific rigour associated with clinical trials. There does seem to be, however, considerable anecdotal and case report data for a beneficial effect of lavender in pain. Using a quasi-experimental cross-over study Brownfield (1998) showed that massage with lavender oil (*L. angustifolia*) reduced the patients' perception of pain and improved the perception of sleep quality and well-being in those suffering the effects of chronic rheumatoid arthritis. It is worth noting that the effects reported in this study are related to the patient's own perception of pain, sleep or well-being as the quantitative data from a visual analogue scale did not reveal any reduction in pain levels or sleep improvement. Ghelardini *et al.* (1999) have further demonstrated that *L. angustifolia* oil, as well as linalyl acetate and linalool, possess local anaesthetic activity both *in vitro* and *in vivo*. These authors suggest that the mechanism of action is related to antimuscarinic activity and/or ion (Na^+ or Ca^{2+}) channel blockade.

It is suggested that, as there appears to be a high uptake of aromatherapy as a therapeutic modality by nurses (Trevelyan, 1996), settings with extended nursing care, for example palliative care facilities, are more likely to adopt complementary therapies in a bid to ease the discomfort of the patients. Lavender, along with other essential oils, has a role in reducing the side effects such as aches and pains, hair loss and anxiety associated with either the cancer itself or with the effects of chemotherapy (Nelson, 1997b). Aromatherapy use in palliative care settings has also been reported to be of benefit to the patients (Kite *et al.*, 1998).

The lack of detail in describing the oils used in many of these studies is, however, common and completely confounds comparisons between work from different groups, many of whom may be using different *Lavandula* oils. It is essential that all future clinical studies specify the exact derivation of the oils used in the study and, preferably, include a GC/MS profile of the liquid or the percentage composition of the major constituents.

EFFECTS ON OTHER BODY SYSTEMS

Apart from actions in the central nervous system lavender has been shown to have antispasmodic actions on both intestinal (ileum) and uterine smooth muscle in animal studies. It has been suggested that these relaxant activities in smooth muscle contribute to the relaxant effects in humans (Lis-Balchin and Hart, 1999). Studies designed to elucidate the mechanism of action of lavender revealed that the antispasmolytic actions were not mediated by either adrenergic or cholinergic receptors, nor actions at calcium or potassium channels (Lis-Balchin and Hart, 1999), rather, lavender was thought to act via an increase in intracellular cAMP. Whether this is linked to receptor activity or not is still unknown, it is also unclear whether the relaxant effects seen in humans are the result of central nervous system actions (via the olfactory and limbic system) or whether the action is mediated peripherally. These actions on smooth muscle, and hence vasodilation, may also be responsible for the reported hypotensive actions of lavender, and may be attributable to the linalool content of lavender oil (Tisserand and Balacs, 1999).

Lavender oil has also found several uses in midwifery where it can be added to bath water to relieve pain and discomfort following labour. In a large clinical trial it was shown that the mothers using lavender oil consistently reported lower discomfort scores 3 to 5 days post-natally (Dale and Cornwell, 1994; Cornwell and Dale, 1995). Lavender oil is also currently used in many delivery rooms for its general calming action. In the past, lavender poultices were applied to the small of the back during labour, to relieve muscle tension, or to the abdomen, to assist placental expulsion. There does not appear to be any scientific evidence for the latter two uses, however, the inhalation of the oil may have an anti-anxiety and relaxing action which is beneficial to the mother.

It has also been suggested that the aroma of some essential oils (e.g. rosemary and lavender) can act as ergogenic aids in sports training. Welker *et al.* (1998) tested this by evaluating oxygen consumption, heart rate, respiratory exchange ratio and rating of perceived exertion in a group of five subjects undergoing submaximal exercise (treadmill walking). Subjects inhaled the fragrance both before and at 3-min intervals during the exercise. No significant difference was found between any parameters when comparing either lavender with other essential oils (basil, rosemary or peppermint) or with the placebo, suggesting that the aromas had no physical benefits during submaximal exercise. However, this study did not assess other parameters (e.g. maximum duration of exercise that could be sustained) or any psychological benefits that may arise and indirectly improve performance. In addition, the results suggest that while these individuals perceived that they were exerting themselves (8–9 on a scale of 1–10), the physiological data indicate that the individuals were not working particularly hard. This may have implications for the extrapolation of these results to trained, fit, athletes. In a study of physical response to exercise (rhythmic handgrip) Nagai *et al.* (2000) found that inhaling pleasant odours (subject's choice of lavender, lemon, rose or other oil) during exercise produced a significant drop in diastolic blood pressure. No other parameters (e.g. finger pulse amplitude, systolic blood pressure and respiratory rate) were affected. Unfortunately no attempt was made to distinguish been the various oils that were used. Another group (Romine, *et al.*, 1999) also failed to find an effect of lavender aromatherapy on cardiovascular measures (blood pressure, heart rate, pulse pressure) during recovery from moderate exercise. However, the authors attribute failure to reach statistical significance to the small group size (10 participants) rather than to any lack of effect. This problem of small group size was noted by all authors and continues to be one of the major obstacles in determining whether or not lavender, or any other essential oil, has beneficial effects in exercise or exercise recovery.

LAVENDER AS AN ANTIMICROBIAL AGENT

Lavender oil (primarily *L. angustifolia*) has been found to be active against many species of bacteria and fungi (Lis-Balchin *et al.*, 1998; Hammer *et al.*, 1999). It has also been suggested that essential oils, including lavender, may be useful in treating bacterial infections that are resistant to antibiotics. For example, *L. angustifolia* oil was demonstrated to have *in vitro* activity against both MRSA (methicillin-resistant *Staphylococcus aureus*) and VRE (vancomycin-resistant *Enterococcus faecalis*) at a concentration of less than 1% (Nelson, 1997a).

Both the oil and oil vapour have been demonstrated to possess some antifungal activity. *L. angustifolia* (1% and 10%) inhibited conidium germination and germtube growth of the fungus *Botrytis cinerea* (Antonov *et al.*, 1997) although conidial production of *Penicillium digitatum* was not affected by *L. angustifolia* at concentrations up to 1000 μg/mL (Daferera *et al.*, 2000). The *L. angustifolia* oil was demonstrated to be more effective in the inhibition of germtube growth than of hyphal growth. Strangely, one report has demonstrated that the growth of four species of filamentous fungi was suppressed by gaseous contact with lavender oil (*L. angustifolia*) but not solution contact (Inouye *et al.*, 1998). This was reported to be caused by the direct binding of gaseous oil on the arial mycelia that formed the spore-forming organ. Little binding was found to occur by solution contact. When the activity of two major constituents was examined, linalyl acetate was found to be capable of suppressing spore formation while linalool was not inhibitory for sporulation but was effective for the inhibition of germination and fungal growth. The inhibition of sporulation appeared to arise from respiratory suppression of arial mycelia.

Lavender vapour has also been shown to inhibit the mycelial growth of *Aspergillus fumigatus*, however, the effect only lasted until the vapour was removed and the dose required (63 mg/mL air) was comparable to that of tea tree oil, but higher than that of lemon grass, cinnamon bark and thyme oils (Inouye *et al.*, 2000). Suppression of the apical growth by vapour contact was ascribed to the direct deposition of essential oil on fungal mycelia, together with an indirect effect via absorption through the agar medium. Similarly, *L. angustifolia* oil at an initial dose of 10–20 μg/mL of air was able to inhibit germination and hyphal elongation of both *Trichophyton mentagrophytes* and *Trichophyton rubrum* and 60 kill conidia at the higher dose of 150 μg/mL of air (Inouye *et al.*, 2001a). These authors state that vapour treatment has an advantage over solution treatment in that the microbial growth could be inhibited by a smaller amount of essential oil while also acting as a potent inhibitor of sporulation. An important factor in the inhibition of the growth of pathogens by gaseous treatment with essential oils, are the vapour concentration and its duration time. It was reported, in this respect, that gaseous contact activity was determined mainly by the maximum vapour concentration at an early stage of incubation and that maintaining a high vapour concentration for long periods of time was not necessary. The effective vapour concentration of linalool against *T. mentagrophytes* was found to be 0.7 μg/mL of air and was higher than that used in aromatherapy (Inouye *et al.*, 2001a).

Extensive research is now being carried out worldwide to identify and isolate the chemical components of lavender oil. This research will allow the identification of biologically active constituents of the oil and the determination of any synergistic effects of the 'mixed' components. While it is known that the main constituents play a major role in the biological activity of lavender oil, it has also been reported that the antimicrobial activity of different types of lavender oil are not all related to these major constituents and very little is known of any synergistic relationships that occur between the oil constituents. For example, studies investigating the relationship between the biological activity and the chemical composition of lavender have found no correlation between the linalool or linalyl acetate content and the antibacterial or antifungal activity (Lis-Balchin *et al.*, 1998). Indeed there was considerable variation between different lavender samples, for example lavender of Bulgarian origin (51.9% linalool, 9.5% linalyl acetate) was effective against 23 of 25 bacteria while a sample of lavender of French origin (29.1% linalool, 43.2% linalyl acetate) was only effective against 13 bacteria. The two oils also had different activities against the fungi *Aspergillus niger* and *Fusarium culmorum*. Interestingly two Bulgarian lavender samples extracted by different means (steam distillation vs supercritical carbon dioxide) had similar antibacterial activity but different antifungal activity suggesting that different oil components may be responsible for the activity against different microorganisms. Pattnaik *et al.* (1997) found that linalool, a major component of lavender oil, could inhibit 17 of 18 bacteria (Gram-negative and Gram-positive bacteria) and 10 of 12 fungi (filamentous and non-filamentous) that it was tested against.

Comparison of data relating to antimicrobial activity *in vitro*, however, is often problematic. When one reviews the literature relating to the antimicrobial activity of essential oils, including lavender, a vast range of methodologies have been used. The most popular methods employed are disc/well diffusion or the agar/broth dilution method. Both the diffusion and dilution methods have been developed to be accurate measures of antibacterial activity and are routinely used in antibacterial susceptibility testing. It is important to note, however, that the substances regularly tested by these methods are generally hydrophilic in nature and so the tests have been optimized to this condition. Essential oils are volatile, insoluble in water, viscous and complex substances and the simple tests described above are inadequate for the antimicrobial testing of oil. The variation in methodology includes factors such as inoculum size, medium used, use of sealants and the use of surfactants and solvents such as Tween, dimethylsulphoxide and ethanol. For example, it has been reported that the minimum inhibitory concentrations (MIC) of both *L. angustifolia* oil and linalool against fungi were reduced more than two to four fold by sealing the medium to prevent the evaporation of the essential oil constituents during incubation (Inouye *et al.*, 2001a). There is, therefore, a need for a standard, robust, reproducible method for assessing essential oils as currently many methods are employed with no standardization occurring. This flaw makes direct comparison between published results virtually impossible.

This is often further complicated by the lack of detailed reporting of which lavender oils were used and which specific variety the oil was derived from. Recent results from this laboratory have found that considerable variation exists in the antimicrobial properties of various lavenders, with some species displaying excellent antibacterial/antifungal activity whilst others have apparently no antibacterial/antifungal activity whatsoever. This antimicrobial testing has included a range of Gram-positive, Gram-negative and spore forming bacteria, yeast and fungi. The antimicrobial activity of lavender oil appears to be influenced not only species but also by growth conditions and distillation procedures (unpublished results).

Despite the known antimicrobial activity, questions remain about the clinical utility of lavender oil. The *in vitro* antimicrobial activity of lavender oil is comparable to that of tea tree, with the MIC values of lavender oil (*L. angustifolia* and *L. latifolia*) being reported as 0.16% against *Haemophilus influenza*, 0.32% against *Streptococcus pyogenes* and *Staphylococcus aureus* and greater than 0.32% against *Escherichia coli* (Inouye *et al.*, 2001b). These values, however, suggest that lavender oil may not be therapeutic against deep seated infections but may be useful as a prophylactic or topical application for surface infection.

Another important factor which must be taken into account in clinical trials are any modulating effects, such as the immunostimulating, antiinflammatory and other pharmacological effects of lavender oil, which assist the recovery from infectious conditions. Although the *in vitro* activity of *L. angustifolia* oil has been intensively investigated, no *in vivo* study has been reported using an experimental infection model and reports of human clinical trials are both limited and inconclusive. For example, one double blind trial investigated the potential of essential oils in preventing infection in chronic bronchitis patients (Ferley *et al.*, 1989). A prophylactic dose of 20 drops of an oil blend, consisting of mint, clove, thyme, cinnamon and lavender, was administered three times daily for 5 months. The overall number of supervening infections and their characteristics were not modified by the treatment, however, the frequency of relapse was significantly lowered in the treated group.

PESTICIDAL ACTIVITIES OF LAVENDER OIL

Several papers have demonstrated that both linalool and *L. angustifolia* oil have ascaricidal activity. In a study investigating the effect of *L. angustifolia* oil and linalool on *Psoroptes cuniculi*, ascaricidal activity was not only related to direct contact with the mites but also when the volatiles were inhaled (Perrucci *et al.*, 1996). Lavender oil or powdered foliage and flowers may also be useful as both commercial (e.g. in grain silos) and domestic pesticides as the application of lavender deters mites, grain weevils, aphids and clothes moth (Perrucci, 1995; Ignatowicz, 1997; Plarre *et al.*, 1997; Hori, 1998). Lavender oil is even being investigated, and showing potential, as a therapeutic agent against the mite that causes psoroptic mange in sheep (O'Brien, 1999).

DERMATOLOGICAL USES OF LAVENDER

Lavender oil has a history of use in wound healing and although it was reported to be particularly effective during World War I there is little or no scientific evidence that lavender accelerates wound healing or reduces scarring. Lavender has also been promoted as an oil that can help relieve the symptoms of other skin conditions such as psoriasis, dermatitis and eczema. It has also been suggested that topical application of lavender oil may actually inhibit parts of the allergic pathway (Kim and Cho, 1999).

As with use of any essential oil there are concerns about the potential for either allergic or skin irritation reactions with the use of lavender. Tisserand and Balacs (1999), in their often cited text on essential oil safety, state that *L. latifolia* and *L. angustifolia* do not produce skin sensitization and are only mild skin irritants and *L. angustifolia* does not produce phototoxicity. However, these authors do not cite evidence in support of these claims. Some studies have found that contact dermatitis is much less frequent following lavender exposure than following contact with other oils such as tea tree (Thomson and Wilkinson, 1998) while others report that lavender is commonly responsible for dermatitis (Clinical, 2000). One study in Japan over a 9 year period found that up to 13.9% of subjects had contact dermatitis on exposure to lavender oil (Sugiura *et al.*, 2000). Further, these authors noted an increase in the rates of contact dermatitis associated with increased use of dried lavender products during the later stages of their study. This time period (1997) corresponds to a time when there was worldwide increased use of essential oils and it might be suggested that contact dermatitis and other skin reactions become more prevalent as product use increases. There are also reports of contact dermatitis due to use of lavender pillows (Coulson and Khan, 1999) and reactions due to cross-sensitivity with other members of the Labiatae family (Benito *et al.*, 1996).

Childhood eczema presents as skin irritation that is difficult to resolve and causes considerable distress to both child and parents. Lavender and other essential oils have been trialed as an alternative to conventional *pharmaceuticals* (e.g. topical steroids) which are often shown to have limited usefulness. Anderson *et al.* (2000) assessed the benefit of a range of essential oils, including lavender, in the treatment of eczema by using both massage with the oils and addition of the oils (6 drops of a mix of 3 oils in 1:1:1 ratio) to bath water. Treatment lasted for 8 weeks and although the sample was small (16 children) there was a considerable improvement in the levels of irritation and night-time disturbance in both the essential oil and massage only groups. There was no significant difference between the aromatherapy massage and massage only groups, however, as noted by the authors, it is difficult to separate the tactile effects of the massage from that of the aroma. Walsh (1996) reported that 14 of 15 individuals with moderate to severe psoriasis treated with essential oils, including lavender, had an improvement in physical symptoms, confidence and self-esteem. It was also noted that family members also benefited from the treatments either by inhaling the vapour of the oils or assisting with application of the oils. While this may seem a remarkable result it should also be noted that this report is not of a clinical trial and that the exact nature of the treatment is not given nor is there any objective before and after treatment severity rating.

Along with rosemary oil, cedarwood and thyme, lavender is believed to promote hair growth in those with alopecia. This effect was studied by Hay *et al.* (1998) using a randomized, double blind, controlled trial. Eighty-six patients with alopecia areata massaged a mix of *Rosmarinus officinalis* (114 mg), *Cedrus atlantica* (94 mg), *Thyme vulgaris* (108 mg) and *L. angustifolia* (108 mg) oil into their scalps each night and hair growth was assessed at 3 and 7 month intervals. Nineteen out of thirty five individuals reported an improvement in hair growth following treatment with essential oils compared with only six out of twenty eight of the controls with a significant reduction in area of alopecia in the treated group compared with the controls.

CONCLUSION

Lavender essential oil is used in a wide range of both cosmetic and therapeutic settings, and oils from a variety of lavender species have been demonstrated to have a range of biological activities. However, there is still considerable debate about whether *Lavandula* oils do have a significant clinical potential either in their own right or as additives to other products. The lack of consistent methodology, inadequate reporting of oil types used and the lack of infection models have severely hampered the analysis and determination of potential therapeutic, clinical, significance. It is essential that standard methodologies be adopted that allow for direct comparison of these, and other, essential oils. Likewise, the psychological and/or physiological effects, in relation to the benefits seen with lavender, and other essential oils, following use as an aromatherapy massage oil, remain to be determined. More accurate reporting and data analysis are, again, required.

A greater appreciation of the differences, not only between the oils produced by the various members of the *Lavandula* family but also between the constituents and efficacy of the whole oil compared with volatiles is essential. Many of the controversies in the literature regarding the activity of *Lavandula* oils may indeed be explained by differences in chemical profiles between the various lavenders. These issues will need to be resolved before we have a true picture of the bioactivity, therapeutic potential and clinical utility of lavender essential oils.

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