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Notes on Minor Oils.
– Leaf oil of *Backhousia citriodora* F. Muell.

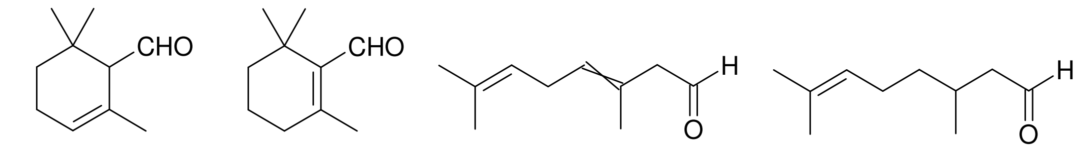
(N.B. Some material updated from monograph in *Natural Aromatic Materials – Odours & Origins* by Tony Burfield (2000) pub AIA Tampa).

Synonyms
Lemon myrtle; lemon scented myrtle; lemon scented ironwood.

Distribution.
Backhousia is a small genus of 6 or 7 spp. named after a British botanist, James Backhouse (1794 – 1869) and which is mainly found in parts of Queensland & the New South Wales coast in Australia, especially the coastal rainforest area from Brisbane to Mackay. The essential oil of *Backhousia citriodora* is steam distilled from the fragrant, shiny, lanceolate leaves of the fast growing evergreen tree *Backhousia citriodora* F. Muell., which, under perfect conditions, can grow to 20 to 30m., but is rarely seen above 5m. when cultivated. Doran (2001) reports its natural occurrence more specifically in the Sunshine Coast vicinity of Eumundi, Macoochydore, Noosa and Woondum in the ranges of Miriam Vale, in the Mackay/Whitsunday/Townsville region and near Herberton. Doran (2001) further describes the reduction of the population size for land clearing for agriculture and land development, and in whole tree harvesting for leaf oils. State Forest or National Park populations are described as 'well protected'. *B. citriodra* is also now found in locations in South Africa, USA and Europe. Doran J.C. (2001) further describes the search and rediscovery of the *L*-citronellal chemotype of the tree, following the changes to the natural habitats of trees brought about by creeping urbanisation, the clearance of land for agricultural purposes and the action of logging companies. The same author describes oils produced in the year 1999 from 3 individual trees giving oils containing 85-89% citronellal and 6-9% isopulegol isomers.

Composition.
Leaves for distillation were originally gathered from the wild, but the species has been cultivated on a small scale since 1991 (the trees can be coppiced to assist leaf-gathering); the pale yellow to yellow coloured essential oil yield is 0.7% to 1.0%, although modern steam stills may give yields in excess of 3.5%. The oil was was first described commercially by Schimmel and Co. in 1888, and a

monograph on the oil appears in Arctander. The composition of the leaf oil is 90-95% citral, with some variable presence of citronellal, myrcene, methyl heptenone, linalol, and α- and β-cyclocitrals. Fergeus (2000) disputes the presence of cyclocitrals and notes the presence of *cis*- and *trans*- isocitral, *trans*-isogeranial and exo-isocitral. The oil was formerly used as a source of citral for ionone production, but it was unable to compete on cost with citral ex lemongrass oil. The introduction of citral ex *Litsea cubeba* oil has given additional competition, but now there is a small market for the oil in its own right following its re-cultivation in Australia in the 1990's.



Odour Characteristics
In a review of the leaf oils of the genus *Backhousia*, Brophy (1995) describes 2 chemotypes for *B. citriodora*, one predominating in citral, the other predominating in *laevo*-citronellal. The odour of the citral chemotype is fresh lemoney, with a hint of lime. It is delicate and pleasant. The odour is distinct from the lemon impression of lemongrass oil, being much cleaner and uncoloured with grassy and oily notes, and free from dry leathery notes associated with mature lemongrass oil. The **dry-out** is disappointing, being faint-lemon and slightly dirty. It was used at one time in soap perfumery to attain a sweet citrus note (gives surprisingly fresh lemon notes to citrus soap perfumes- TB).

Regulatory.
Backhousia citriodora leaf extract CAS No: 84775-80-4; EINECS No: 283-909-7.
Hazard symbol Xi - Irritant
R- and S-phrases R38-43; S24/25-37.

Backhousia citriodora oil is a pleasant enough high-citral containing oil produced in Australia, which is a useful ingredient in perfumery / natural perfumery. Some unfortunate instances of adulteration have occurred recently, prompting the responsible officials in Standards Australia to consider adjusting the existing Australian Standard (AS 4941 – 2001) to prevent further occurrences of adulteration, In spite of objections, the committee have drawn up a standard for *B, citriodora* oil with a citral content of over 90%, a figure that many growers and distillers cannot achieve. In our opinion this makes adulteration *more* likely, so that *B. citriodora* essential oils pass the standard. Cropwatch's advice is to ignore the Australian standard if you are looking to purchase an authentic *B. citriodora* oil.

The 22nd meeting of the Complementary Medicines Evaluation Committee (CMEC) of 25th Aug 2000 recommended to the Therapeutic Goods Administration (TGA) of the Australian Government that *Backhousia citriodora* leaf oil at a concentration not exceeding 1% (w/w) is suitable for use in listable therapeutic goods for topical use (Item 6.2 Recommendation 22.4).

Bibliography.

Ahmed A.K. & Johnson K.A. "Turner Review No. 3. Horticultural development of Australian native edible plants." *Australian J Botany* **48**(4) 417 - 426. Abstract. The Australian native edible plant industry is rapidly expanding. We provide a review of the horticultural research that has been carried out on the top 14 commercially significant Australian native edible plants; *Acacia* spp. Miller (wattle), *Acronychia acidula* F.Muell. (lemon aspen), *Backhousia citriodora* F.Muell. (lemon myrtle), *Eremocitrus glauca* (Lindl.) Burkill (desert lime) and *Microcitrus* spp. Swingle (native lime), *Hibiscus heterophyllus* Vent. and *Hibiscus sabdariffa* L. (rosella), *Kunzea pomifera* F.Muell. (muntries), *Podocarpus elatus* R.Br. ex Endl. (Illawarra plum), *Prostanthera* spp. La Billardiere (native mint), *Santalum acuminatum* R.Br. (quandong), *Solanum centrale* Black (bush tomato), *Syzygium leuhmannii* F.Muell. (riberry), Tasmannia spp. R.Br. (native pepper), *Terminalia ferdinandiana* (= *T. latipes* Benth. subsp. *psilocarpa* Pedley) (kakadu plum) and *Tetragonia tetragonioides* (Pallas) Kuntze (warrigal greens). The research on most of these species has focused on propagation, breeding, cultivation, nutritional value and the isolation of natural products. On none of the species has research been completed in all these areas, and three species have no research published on them. We describe horticultural research on two other commercial species, *Backhousia anisata* Vickery (aniseed myrtle) and *Davidsonia pruriens* F.Muell. var. *pruriens* and var. *jerseyana* (Davidson's plum), and one species with commercial potential, *Pringlea antiscorbutica* R.Br. ex Hook.f. (kerguelen cabbage). We identify areas that require further research and issues of concern, such as indigenous intellectual property rights and environmental implications.

Archer, Dennis (2004) *Backhousia citriodora F. Muell Lemon Scented Myrtle - Biology, Cultivation & Exploitation*. Pub: Toona Essential Oils Pty. Ltd. (2004) ISBN 0 9751845-0-4. *Cropwatch Review* Dennis Archer has used his knowledge and experience of raising Australian aromatic plants and the Australian essential oil trade, to produce an informative and attractive 87 page book, well illustrated with photographic shots of the subject matter. The book is authoritative and presents an overview of the position of the oil in relation to the history of the Australian oils industry, and the potential of the oil for end-user applications today. Chapter subjects include the history of *Backhousia citriodora,* the Biology, Silviculture, Exploitation and Research, with appendices covering safety and handling of the oil. With a more critical eye, it is hard to fault much of the contents – the chapter on the history of the plant for example is well researched and comprehensive, going back to the first literature mention of Shimmel & Co. of Dresden in 1888. The chapter on biology covers the morphological aspects of the tree, foliage, flowers and seeds, wood and plant genetics generally. Chemotypes are also mentioned - variety "A" – first mentioned in 1950 and rediscovered in 1996 - being particularly rich in *laevo*-citronellal at the expense of the citral content. The 21-page, lavishly illustrated silviculture chapter, gives way to a

chapter on Exploitation which is perhaps from the reviewers point of view, is amongst the most interesting parts of the book. A thorough account of harvesting follows a discussion of the analysis of the commercially available oils - the composition of the normal oil (as distinct from the *laevo*-citronellal type) revealing a high citral content. A chapter on research (applications) and a concluding page complete the text. In general terms it is a pleasure to see such a specialist area being so well covered in such a competent manner. If I had any criticisms at all of the publication, it would be to include more on potential applications - suggestions for uses in perfumery & natural perfumery (as either a modifier or dominant ingredient for citrus top notes, airfreshner perfumes etc.) - and to cover more fully the potential microbiological applications. The fact that citral is an irritant and an allergen (see 7th Amendment to the EU Cosmetics Act) and binds to dermal proteins, may of course limit its potential applications in mainstream skin perfumes, and in aromatherapy massage. But for non-skin and biocidal applications, the oil of *Backhousia citriodora* has some interesting properties which may justify its' extra cost over other high citral-containing oils such as *Litsea cubeba* – again something not quite fully bought out in the text. Nevertheless, I would sincerely recommend this publication for a place in the serious essential oil user's library.

Brophy J.J., Goldsack R.J., Fookes C.J. R. & Foster P.I. (1995) Leaf oils of the genus *Backhousia* (Myrtaceae). *Journal of Essential Oil Resources* **7**, 237-254.

Buchaillot A., Amandine C., Caffin N. & Bhandari B. (2009) "Drying of Lemon Myrtle (*Backhousia citriodora*) leaves: Retention of volatiles and color." *Drying Technology* 27(3), 445-450. Abstract. Lemon myrtle plant (*Backhousia citriodora*) leaves were dried at three different drying temperature conditions (30, 40, and 50℃) in a fluidized bed dryer. The retention of the principal volatile compound, citral, was analyzed in dried products obtained at these three drying conditions. The changes in the color parameters L*, a*, b* of leaves were also analyzed. More than 90% of citral was retained at 50℃ drying temperature, whereas the retention at 30 and 40℃ was 81 and 85%, respectively, suggesting that higher temperature is beneficial to achieve higher retention of volatiles. However, in terms of the color, all the color parameters were changed maximum at 50℃ drying temperature unfavorably, suggesting that the higher temperature drying causes more degradation of the pigment. Blanching of the leaves in hot water at 80℃ for 1 min prior to drying did not result in any improvement in volatile retention or color

Burke B.E., Baillie J.-E. & Olson R.D. (2004) "Essential oil of Australian lemon myrtle (*Backhousia citriodora*) in the treatment of molluscum contagiosum in children." *Biomedicine and Pharmacotherapy* 58(4), 245-247. Abstract. Molluscum contagiosum is a common viral illness of childhood and is increasingly found as a sexually transmitted disease in sexually active young adults. Current treatment options are invasive, requiring tissue destruction and attendant discomfort. Thirty-one children (mean age 4.6 +/- 2.1 years) with the diagnosis of molluscum contagiosum (mean length of time with condition 8.6 +/-

5.3 months) were treated with once daily topical application of a 10% solution (v/v) of essential oil of Australian lemon myrtle (*Backhousia citriodora*) or vehicle (olive oil). At the end of 21 days, there was greater than 90% reduction in the number of lesions in 9/16 children treated with lemon myrtle oil, while 0/16 children met the same criteria for improvement in the vehicle group (P < 0.05). No adverse events were reported.

Chen W. (1997) "Genetic variation in oil, growth and propagation traits of *Backhousia citriodora* (F. Muell), and implications for breeding strategy." Australian National University, Canberra, ACT.

Cock I.E. (2008) "Assessment of the toxicity of selected Australian native plant extracts using the *Artemia franciscana* nauplii bioassay." *The Internet Journal of Toxicology* 2008: **5**(2). Abstract. Thirty nine methanolic extracts from twenty five Australian native plants were investigated for toxicity using the *Artemia franciscana* nauplii lethality bioassay and compared to the reference toxins potassium dichromate and Mevinphos. 7 extracts (18 %) showed marked lethality towards *Artemia franciscana* nauplii at 24 h, 11 extracts (28 %) at 48 h and 19 extracts (49 %) at 72 h. Of the positive controls, only Mevinphos displayed significant lethality at 24 h. Potassium dichromate treatment resulted in only approximately 10 % mortality at 24 h but induced 100% mortality by 48 h. Of the non-toxic extracts, *A. aulacocarpa* leaf, *L. bracteata* leaf, *L. juniperium* leaf and flower, *S. australe* leaf and *B. celsissima* leaf extracts have previously been shown to be good antibacterial agents, confirming their potential for antibiotic usage. ***Cropwatch comments*** The authors describe brine shrimp larvae lethality bioassay tests which indicated that *Backousia citriodora* extract was lethal to *Artemia franciscana* at 1000μg/ml at 72 hours exposure. The authors also note that this result is is in contrast to the findings of Setzer *et al.* (2001) who used both *Artemia franciscana* and human cells lines, finding no toxicity using *Backousia citriodora* extracts of lower concentration (250μg/ml) with exposure times unnoted. Ref: Setzer M.C., Setzer W.N., Jackes B.R., Gentry G.A. & Moriarity DM (2001) "The medicinal value of tropical rainforest plants from Paluma, North Queensland, Australia" *Pharmaceutical Biology* **39**(1), 67-78.

Doran J.C., Brophy J.J., Lassak L.V. & House A.P.N. (2001) "*Backhousia citriodora* F. Muell. - Rediscovery and chemical characterization of the L-citronellal form and aspects of its breeding system." *Flavour and Fragrance Journal* 16(5), 325 - 328. Abstract. The rare L-citronellal form of *Backhousia citriodora* F. Muell. was first reported in 1950 but attempts to relocate it were unsuccessful until 1996. The quest to relocate trees of this type has been driven by interest in L-citronellal for perfumery. The common, citral form of the species is already under cultivation for oil production in Australia. This paper reports on the rediscovery of the L-citronellal form, first in 1996 in a year-old provenance/progeny trial of *B. citriodora* in south-eastern Queensland, and then in a natural population on Queensland's Sunshine Coast in 1998. The three L-citronellal trees in the trial gave foliar oil concentrations (g/100 g dry weight) of 3.2, 2.2 and 1.8, respectively, when sampled in November 1996. The same trees

sampled in March 1999 gave pale yellow oils consisting of 85-89% citronellal, 6-9% isopulegol isomers with small quantities of citronellol (approx. 3%) and several other compounds. Data on the physicochemical properties of these oils are given in the paper. Seed from a single mature L-citronellal tree gave progeny of both the L-citronellal and citral form in a ratio of approximately 1 : 1. Propagation material from many more plants of the L-citronellal form needs to be collected and assembled in breeding populations. This would form the basis of a selection and breeding programme, should this chemotype show economic potential.

Dupont S., Caffin N,, Bhandarib B. & Dykes G.A. (2005) "In vitro antibacterial activity of Australian native herb extracts against food-related bacteria." *Food Control* **17**(11), 929-932. Abstract. The antibacterial activities of water, ethanol and hexane extracts of five Australian herbs (*Backhousia citriodora*, *Anetholea anisata*, *Eucalyptus staigerana*, *Eu. olida* and *Prostanthera incisa*) against seven food-related bacteria (*Enterococcus faecalis*, *Escherichia coli*, *Listeria monocytogenes*, *Pseudomonas aeruginosa*, Salmonella *enteritidis*, *Sal. typhimurium* and *Staphylococcus aureus*) were determined by the microtitre broth microdilution assay. The water extracts of all the herbs displayed no or low antimicrobial activity against all of the bacteria tested with the exception of S. aureus. Relatively high levels of activity (minimum inhibitory concentrations of 125–15.6 μg ml–1) against this pathogen were present in water extracts from all herbs except *P. incisa*. The ethanol and hexane extracts of all herbs displayed some activity against a number of the bacteria tested, with no one particular herb displaying an obviously higher level or range of activity. *Staphylococcus aureus* proved to be the most sensitive of the bacteria tested against the solvent extracts with all extracts displaying activity ranging from 125 to 7.8 μg ml–1, while E. coli and *L. monocytogenes*, on the other hand, proved the least sensitive with only five of 15 herb/extract combinations displaying any activity against these pathogens. The extracts of the Australian native herbs examined in this study have potential for application in foods to increase shelf-life or promote safety.

Fergeus J. (2000) “What will be the next big oil from Australia?” *Perf. &Flav.* Vol **25**(6) Nov/Dec 2000 p16-17.

Harris B. (2004) “Research Reports” *International J of Aromatherapy* **14**(4), 202-4. ***Cropwatch comments:*** Includes feature on Anti-viral Lemon Myrtle.

Hayes A.J. & Markovic B. (2002) "Toxicity of Australian essential oil *Backhousia citriodora* (Lemon myrtle). Part 1. Antimicrobial activity and in vitro cytotoxicity." *Food Chem Toxicol*. **40**(4), 535-43. Abstract. The antimicrobial and toxicological properties of the Australian essential oil, lemon myrtle, (*Backhousia citriodora*) were investigated. Lemon myrtle oil was shown to possess significant antimicrobial activity against the organisms *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida albicans*, methicillin-resistant *S. aureus* (MRSA), *Aspergillus niger*, *Klebsiella pneumoniae* and *Propionibacterium acnes* comparable to its major component-citral. An in vitro toxicological study based on the MTS (3-(4,5-dimethylthiazol-2-yl)-5-(3-carboxymethoxyphenyl)-2-(4-

sulfophenyl)-2H-tetrazolium) cytotoxicity assay was performed. In vitro cytotoxicity testing indicated that both lemon myrtle oil and citral had a very toxic effect against human cell lines: HepG2 (a hepatocarcinoma-derived cell line); F1-73 (a fibroblast cell line derived from normal skin) and primary cell cultures of human skin fibroblasts. Cytotoxicity IC50 (50% inhibitory concentration) values ranged from 0.008 to 0.014% (w/v) at 4 h to 0.003-0.012% (w/v) at 24 h of exposure. The no-observed-adverse-effect level (NOAEL) for lemon myrtle oil was calculated as 0.5 mg/l at 24 h exposure and the RfD (reference dose) was determined as 0.01 mg/l. A product containing 1% lemon myrtle oil was found to be low in toxicity and could potentially be used in the formulation of topical antimicrobial products.

Hayes A.J. & Markovic B. (2003) "Toxicity of Australian essential oil *Backhousia citriodora* (lemon myrtle). Part 2. Absorption and histopathology following application to human skin." *Food Chem Toxicol*. **41**(10), 1409-16. Abstract. The in vitro percutaneous absorption of the essential oil of lemon myrtle (*Backhousia citriodora*) has been studied in freshly excised human full-thickness abdominal skin obtained from patients undergoing elective surgery. Absorption of lemon myrtle oil in human skin discs (4.9 cm(2)) was evaluated using a Franz cell diffusion system following topical application of neat lemon myrtle oil (100 microl or 18.29 mg/cm(2)) to the epidermal surface at exposure durations of 1 to 12 h. Gas chromatography mass spectrometry (GCMS) was used as an analytical technique to determine the absorption of lemon myrtle oil components in full-thickness skin. Citral; (consisting of isomers, geranial and neral) was the only component of lemon myrtle oil found to be absorbing into skin at all exposure periods. At the maximum exposure duration of 12 h, the total absorption of citral in the full-thickness skin disc was 0.29+/-0.07 mg/cm(2) (mean+/-S.D., n=4) of the applied dose. Although the absorption of lemon myrtle oil components was limited, haematoxylin and eosin (H&E) staining showed significant losses in the cellular functioning of skin including; losses of integrity and solubilisation of the stratum corneum, cellular necrosis (to 15%) and cellular vacuolation (to 25%) on comparison to control skin. When a formulated product containing 1% lemon myrtle oil (0.18 mg/cm(2)) was applied to human skin discs (4.9 cm(2)) at 8 h exposure the total absorption of citral in the full-thickness skin disc was 5.12+/-0.60 x 10(-4) mg/cm(2) (mean+/-S.D., n=4) of the applied dose. No other components were detected. The histopathological assessment indicated limited damage to epidermal cells. The combination of the above methodologies enabled the generation of data that could be used for a comprehensive evaluation of the toxicity effects of lemon myrtle oil for topical application.

Hidayat Y. (2008) *Biological Activities of Plant Extracts and Essential Oils against* Helicoverpa armigera. Masters Thesis Univ of Queensland. Abstract. Hexane, benzene, chloroform and methanol extracts of *Ajuga australis*, *Lantana camara* and *Tithonia diversifolia*, and the essential oils of *Backhousia citriodora*, *Melaleuca alternifolia* and *Melaleuca quinquenervia* were investigated for their biological activities against the cotton bollworm, *Helicoverpa armigera* Hubner. Most noticeable was the antifeedant effect of most of the plant extracts tested on

H armigera. Based on the results of the choice feeding assays, the most effective extracts of each plant were hexane for *A. australis* (AIso=13.5 ~g/cm2), benzene for *T diversifolia* (AIso=43.5 ~g/cm2) and benzene for *L. camara* (AIso=99.7 ~g/cm2). For the three essential oils tested, only the essential oil of *B. citriodora* showed an antifeedant effect (Also choice test = 282.4 ~g/cm2). Among all plant extracts and essential oils investigated in this study, the hexane extract ofA. australis was the most potent antifeedant. None of the plant extracts tested significantly affected the survival of *H armigera* in either feeding or contact assays. Generally, ingesting plant extracts for 12-15 hours in a no-choice feeding assay had no significant effects on the growth and development of *H armigera*. Exceptions were the hexane and chloroform extracts of *A. australis* and the chloroform extract of L. camara, which slightly lengthened the larval development time, and the hexane extract of *L. camara* which slightly reduced the pupal weight. Unlike the plant extracts, or the essential oils of *M alternifolia* and *M. quinquenervia*, the essential oil of *B. citriodora* had an effect on the survival ofH armigera. In a contact assay at the highest dose (200 ~g/larvae), this essential oil killed 33.3 % of the larvae tested after 48 hours. In a no-choice feeding assay, also at the highest dose (500 ~g/cm2), the essential oil of *B. citriodora* had no significant effect on larval survival, but heavily influenced the later development stages of the insect where more abnormal pupae were formed, and not a single adult emerged. Although it is without toxic effect, the Australian native plant, *A. australis* is considered to have the most potential for insect control. Its strong antifeedant effect at a low dose on *H armigera* may have a significant potential role in the implementation of an Integrated Pest Management (IPM) program for this insect.

Hood J.R., Cavanagh H.M. & Wilkinson JM. (2004) "Effect of essential oil concentration on the pH of nutrient and Iso-sensitest broth." *Phytother Res.* 18(11), 947-9. Abstract. The role of pH on the antimicrobial activity of essential oils has not been well studied. The effect of four essential oils: *Backhousia citriodora*, *Melaleuca alternifolia, Lavandula angustifolia* and *Santalum spicatum* (0.1% to 10%) on the pH of two commonly used media, nutrient broth and Iso-sensitest broth, was therefore undertaken. Small (less than 0.5 pH units) but statistically significant differences between the pH of the two media followed the addition of *M. alternifolia*, *L. angustifolia* and *S. spicatum* essential oil. In general the effect on pH was greatest at higher concentrations and the fall in pH was greatest in the nutrient broth. The addition of *B. citriodora* essential oil to nutrient broth resulted in a fall in pH from 7.29 +/- 0.02 (no oil) to 5.2 +/- 0.03 (10% oil). This effect was not observed in the Iso-sensitest broth.

House A. P. N., Walker S. M. & Doran J. C. (1996) "Improvement and propagation of *Backhousia citriodora*, an essential oil bearing species of commercial potential." In: *Tree improvement for sustainable tropical forestry* QFRI-IUFRO, Vol. 1 (Eds, Dieters, M. J., Matheson, A. C., Nikles, D. G., Harwood, C. E. and Walker, S. M.) Queensland Forestry Research Institute.

Huynh T., Caffin N.A., Dykes G.A & Bhandari, B.R. (2008) "Optimization of the microencapsulation of Lemon Myrtle Oil using response surface methodology." *Drying Technology* **26**(3), 357-368.

Kerr J. (2000) "Essential oil profile – Lemon Myrtle." *Aromatherapy Today* **16**, 12-15.

Kibbler H., Johnston M.E. & Williams R.R. (2004) "Adventitious root formation in cuttings of *Backhousia citriodora* F. Muell: 1. Plant genotype, juvenility and characteristics of cuttings *Scientia Horticulturae* **102**(1),133-143. Abstract. *Backhousia citriodora* is a commercially valuable Australian woody species that has a reputation for being recalcitrant in forming adventitious roots from cuttings. A study was carried out to determine whether maturation and plant genotype influenced rooting. It also tried to establish whether genotypic differences in rooting ability were related to characteristics of the cutting material. The rooting of cuttings in *B. citriodora* declines after maturation and is strongly influenced by genotype. The cutting characteristics of actively growing axillary buds, wide stems and mature leaves are associated with rooting and survival but not related to genotype. Furthermore, the 8–24 weeks required *by B. citriodora* to form roots from cuttings makes it difficult to distinguish between the characteristics that increase rooting and those characteristics that enhance survival. A subsequent disbudding experiment demonstrated that axillary buds per se have an inhibitory effect on rooting. This suggests that the presence of actively growing axillary buds are an indication of overall growth and condition of the stock plant unrelated to the formation of adventitious rooting. The effects of other cutting characteristics on rooting are also discussed.

Kibbler H., Johnston M.E. & Williams R.R. (2004) "Adventitious root formation in cuttings of *Backhousia citriodora* F. Muell: 2. Seasonal influences of temperature, rainfall, flowering and auxins on the stock plant." *Scientia Horticulturae* **102**(3). 343-358. Abstract. A 2-year study was carried out on established trees at two sites in southeastern Queensland, Australia, to identify environmental factors that influenced rooting of *Backhousia citriodora* from cuttings. Complex interactions of rainfall events above 20 mm from the preceding month and mean maximum temperature on stock plants resulted in a correlation with rooting success of r=0.81 and 0.74 for sites at The University Of Queensland, Gatton Campus, and Cedar Glen, respectively. A more detailed investigation under controlled environmental conditions showed that maintaining stock plants at temperatures between 10 and 30 °C had no direct effect on rooting capacity. However, temperature was correlated with growth, which may have an indirect effect on root formation. In spring, floral initiation was found to only delay rooting and had no effect on the final rooting percentage. A series of seasonal experiments demonstrated that application of the auxins indole-3-acetic acid, indole-3-butyric acid and napthaleneacetic acid over a range of concentrations (1000–8000 μg/ml) did not significantly increase rooting compared to the control and there is no practical advantage in applying auxins. Seasonal results and the temperature experiment also suggest that under a glasshouse environment with higher temperatures in winter and an adequate supply of water, *B. citriodora* cuttings can be successfully rooted over the whole year.

Kibbler H., Williams C.M., Williams R.R. & Johnston M.E. (2002) *J of ?* "Inhibition of adventitious rooting In *Backhousia citriodora* F. Muell. cuttings correlate with the concentration of essential oil." Summary. *Backhousia citriodora* is typical of the many commercially valuable woody Australian Myrtaceae species that are recalcitrant in forming adventitious roots from cuttings after maturation. A series of experiments were conducted to identify an endogenous rooting inhibitor in line with established criteria. Endogenous levels of citral were correlated with the rooting capacities of juvenile versus mature, and easy versus difficult-to-root genotypes of B. citriodora, in both winter and summer. The biological activity of citral was confirmed in bioassays on mung beans and easy-to-root B. citriodora seedlings. Evidence of a common mechanism of root inhibition with other species in the family Myrtaceae and the role of action of citral are discussed.

Lawrence B.M. (2006) “Progress in essential oils – Lemon Myrtle oil” *Perfumer & Flavorist* Summer 2006 p44.

Nhu-Trang T.T., Casabianca H. & Grenier-Loustalot M.F. (2006). "Authenticity control of essential oils containing citronellal and citral by chiral and stable-isotope gas-chromatographic analysis." *Anal Bioanal Chem*. 386(7-8), 2141-52. Abstract. Enantioselective capillary GC on a Supelco beta-DEX 225 column (heptakis(2,3-di-O-acetyl-6-O-tert-butyldimethylsilyl)-beta-cyclodextrin SPB 20poly--20% diphenyl, 80% dimethylsiloxane) and isotope-ratio mass spectrometry, coupled online with capillary GC on an HP5 column have been used for origin-specific analysis and authenticity control of essential oils, for example lemon (*Citrus limon*), lemongrass (*Cymbopogon citratus* and *Cymbopogon flexuosus*), citronella (*Cymbopogon nardus* L.--Ceylon type and *Cymbopogon winterianus*--Java type), *Litsea cubeba*, *Lippia citriodora*, lemon myrtle (*Backhousia citriodora*), lemon gum (*Eucalyptus citriodora*), and, especially, precious lemon balm oil (*Melissa officinalis* L.). Isotope data (delta13C(PDB) and delta2H(V-SMOW)) for citral (neral + geranial) and citronellal from on-line GC-C/Py-IRMS and chiral data for citronellal in these essential oils are reported. The possibility of using these data to determine the origin of these essential oils and to detect adulteration is discussed. Principal-components analysis (PCA) of specific compounds in two essential oils of lemongrass and *Litsea cubeba* was performed as a practical statistical method for distinguishing between these two types of oil.

Pengelly A. (1991) "Antimicrobial activity of lemon myrtle and tea tree oils." *Aust J of Medical Herbalism* 3(3). Abstract. The composition of the tea tree (*Melaleuca alternifolia*) and lemon myrtle (*Backhousia citriodora*) essential oils was analysed by chiral phase GC-mS. Lemon myrtle oil contained over 96% citral made up of isomers of neral and geranial, while tea tree oil consisted of 42.8% terpinen-4-ol and <5% 1-8 cineol. When tested against pathogenic organisms, such as *Candida albicans, Escherichia coli, Staphylococcus aureus* and *Pseudomonas* *aeruginosa*, lemon myrtle oil showed minimum inhibitory concentration (MIC) values similar to citral, while values for tea tree oil were higher. When varying blends of lemon myrtle and tea tree oils were tested, the blends with higher percentages of lemon myrtle oil consistently presented lower MIC values. In the case of the highly resistant strain *P. aeruginosa*, MIC values were very high compared to other organisms - 2% for lemon myrtle oil and citral, while it was resistant to tea tree oil at 10%, the maximum concentration applied. MTC cytotoxicity assay using human skin cell lines, skin fibroblasts and a liver-derived cell line showed that pure lemon myrtle oil and citral were very toxic, whereas pure tea tree oil was moderately toxic. A 1% lemon myrtle oil product was considerably less toxic, comparable to aspirin used as a baseline standard. From a combination of the data gathered with extrapolations of toxicity studies (including LD_{50} values) for citral, the no observed adverse effect level (NOAEL) was calculated at 0.5 mg/litre at a 24-h exposure, and reference dose (Rfd) was estimated at 0.01 mg/litre. It is concluded that a 1% solution of lemon myrtle oil used in a topical antimicrobial product would be low in toxicity.

Southwell I.A., Russell M.F. & Smith R.L. (2001) "Chemical composition of some novel aromatic oils from the Australian flora." *ISHS Acta Horticulturae 597: International Conference on Medicinal and Aromatic Plants (Part II)* Abstract. The leaves of *Backhousia citriodora*, *B. anisata*, *Darwinia citriodora*, *Acacia nuperrima* ssp. *cassitera* and *Prostanthera staurophylla* were steam distilled and their essential oils isolated and examined by GC and GCMS to determine their chemical composition. *Backhousia citriodora* and *B. anisata* were confirmed as being rich in citral and anethole respectively with rare chemical varieties of each rich in citronellal and methyl chavicol. The chemical and physical characteristics of these oils indicated that these species were ideal alternative sources of citral, citronellal, anethole and methyl chavicol type oils. Similar analysis of the previously unexamined *Darwinia citriodora*, *Acacia nuperrima* ssp. *cassitera* and *Prostanthera staurophylla* showed that these species were potential sources of methyl myrtenate and methyl geranate, kessane and the rare phellandren-8-ol respectively.

Svoboda K.P. & Greenaway R.I. (2003) "Lemon scented plants." *Internat J Aromatherapy* 13(1), 23-32. Abstract. A large number of plant species has wonderful citrus scent, or just a pleasant hint lemon fragrance. Leaves, flowers, needles, cones or wood can be the source of original material. Some plants are old favourites, such as lemon balm (*Melissa officinalis*), lemon thyme (*Thymus×citriodorus*), lemon mint (*Monarda citriodora*) and various *Citrus* species. This review gives a summary of both established and new species on the world market, with detailed description of five more unusual representatives of this group, including the chemicals responsible for the lemon scent.

Taylor R. (1996) “Lemon myrtle: the essential oil.” In *Rural Research* Spring 1996, 172. Melbourne: CSIRO.

Wilkinson J.M., Hipwell M., Ryan T. & Cavanagh HM. (2003) "Bioactivity of *Backhousia citriodora*: antibacterial and antifungal activity." *J Agric Food Chem*.

51(1), 76-81. Abstract. *Backhousia citriodora* products are used as bushfoods and flavorings and by the aromatherapy industry. The antimicrobial activity of 4 samples of *B. citriodora* oil, leaf paste, commercial tea (0.2 and 0.02 g/mL), and hydrosol (aqueous distillate) were tested against 13 bacteria and 8 fungi. Little or no activity was found to be associated with the leaf tea and hydrosol, respectively. Leaf paste displayed antimicrobial activity against 7 bacteria including *Clostridium perfringens, Pseudomonas aeruginosa*, and a hospital isolate of methicillin resistant *Staphylococcus aureus* (MRSA). The 4 essential oils were found to be effective antibacterial and antifungal agents; however, variation was apparent between oils that did not correlate with citral content. The antimicrobial activity of *B. citriodora* essential oils was found to be greater than that of citral alone and often superior to *Melaleuca alternifolia* essential oil. *B. citriodora* has significant antimicrobial activity that has potential as an antiseptic or surface disinfectant or for inclusion in foods as a natural antimicrobial agent.