Australian
Native
Products

Discovering Lemon Myrtle

Contents

Executive Summary

Lemon myrtle is a beautiful and versatile native Australian plant. With its distinctive aromatic lemon flavour and fragrance, and functional benefits, it has enormous potential for commercial production.

Grown in the subtropical rainforests of Australia's eastern coastal hinterlands

Highest known source of citral in lemon-scented herbals

Lemon myrtle can be used in:


Food


Beverages


Aromatherapy


Household cleaning


Personal care

Lemon myrtle comes in all shapes and sizes


Dried leaf


Powder


Essential oil


Extract


Hydrosol


Microfibre

Naturally...


Antibacterial


Antifungal


Antioxidant


Anti-inflammatory

What is Lemon Myrtle?

Lemon myrtle is a species of flowering plant in the family *Myrtaceae*, genus *Backhousia*. Growing up to five metres high, lemon myrtle's hanging branches are adorned with soft green leaves and clusters of creamy white flowers.

Other common names for this native Australian botanical are lemon-scented myrtle, lemon-scented ironwood and lemon-scented backhousia. It is native to Australia's subtropical rainforests located within the coastal hinterlands of central and southeastern Queensland. The biggest commercial plantations of lemon myrtle are in northern New South Wales and Far North Queensland and belong to Australian Native Products.

History

Indigenous Australians have long used lemon myrtle both in cuisine and as a healing plant.[1] Following the colonisation of Australia by the British in 1788, lemon myrtle was given its scientific name *Backhousia citriodora* in 1853 by botanist Ferdinand von Mueller, with the genus named after his friend James Backhouse, a Quaker missionary and botanist.[1]

Lemon myrtle was analysed for its commercial use by early British settlers in 1889, when Joseph H Maiden reported on the potential use of lemon myrtle for commercial production. At around the same time a German company, Schimmel & Co, was the first to isolate and identify citral as the primary ingredient in *B.citriodora* oil.[1]

"The Queen of lemon herbs."

Lemon myrtle has long been used by Indigenous Australians in cuisine and as a healing plant, but it wasn't until 1889 that its potential for commercial production was first investigated.

The antibacterial properties of lemon myrtle's essential oil were first formally studied in 1925.[2, 3]

During the Second World War, lemon shortages led to the first known commercial use of lemon myrtle by the wider Australian population, when it was used as a lemon substitute in a brand of commercial lemonade. Following the war, the commercial use of lemon myrtle declined due to overharvesting, and it was replaced by other citrus-scented plants such as lemongrass.[4]

The 1990s saw a 'rediscovery' of lemon myrtle as a new commercial crop, with commercial orchards becoming more and more common. During the Sydney 2000 Olympic Games, lemon myrtle featured on menus in the Athletes' Village.

Harvesting and preparation

Lemon myrtle in Australia is generally grown in plantations and harvested fresh. It is available year-round.

Trees are hedged to 1.5 – 1.8 metres and are harvested all year round. The tree is left to regrow for 6-12 months before it is harvested again.

The lemon myrtle leaves are the focus of the harvest as they contain the highest levels of the key biological compound called citral. Citral is the compound which gives lemons, lemongrass and lemon verbena their lemony aromatic quality, and is one of the key bioactives that delivers lemon myrtle's functional benefits. (see page 28 for more on citral).

Following the harvest, two separate processes occur. The leaves are separated from the stems and dried using a continuous air drier. The dried leaves are then processed to a variety of cut sizes for use in a range of products. The remaining stems are steam distilled to produce the essential oil. It is also possible to distil the fresh (green) harvest leaves and stems.

Australian Native Products leads the lemon myrtle industry with its processing innovation. Proprietary harvesting techniques, leaf separation and drying technology ensures superior preservation of fragrance and flavour during the processing stage and guarantees the finest and freshest leaf is produced in minimal time from tree to processing facility.

CASE STUDY:
Four Pillars Gin Distillery

Australian Yarra Valley-based distillery, Four Pillars, prides itself on producing a range of uniquely Australian gins, each with a distinct flavour profile that pays homage to its native origin.

Lemon myrtle is one of the native ingredients Four Pillars uses to create fresh citrus notes in its gins. Its ability to pair with juniper, the primary botanical in gin, and to distil without losing its aromatic flavour are two of the key benefits to using lemon myrtle to flavour alcohol.

"In my opinion, lemon myrtle is the Australian native botanical that will continue to put Australian gin on the map. It has lovely citrus notes and when distilled, it rounds out with a beautiful vanilla character, almost like lemon curd," – Cameron Mackenzie, Four Pillars Founder and Distiller

Sustainable production

Being a native Australian plant, commercial lemon myrtle is sustainably grown. Lemon myrtle has very few natural predator pests and is resistant to many diseases common in other exotic tree crops. Australian Native Products has implemented sustainable farming practices to encourage the native flora and fauna to thrive, creating a natural ecosystem to minimise the use of chemicals.

"Lemon myrtle has very few natural predator pests and is resistant to many diseases common in other exotic tree crops."

During the harvest and processing of lemon myrtle, Australian Native Products ensures minimal to zero wastage. For example, hydrosol, or floral water, is a by-product of the distillation process. Given its fragrance and residual citral, it is being developed for use in personal care products.

The distillation process also produces a by-product mulch that when returned to the soil around a young lemon myrtle plant, will prevent the growth of weeds and slow the evaporation of moisture from the soil. Optimal soil health is critical for a lemon myrtle plant's roots to receive the nutrients and enzymes needed to develop.

Packaging

The dried leaves and oils are supplied in a variety of sizes and cuttings, suitable for a variety of products, and appropriate packaging is required to prevent lemon myrtle from losing its volatile oils.

Using the optimum packaging film can extend lemon myrtle's shelf life, but recommendations vary and need careful consideration along with storage temperatures.[5]

Australian Native Products and the University of Queensland are working together on innovations in packaging to ensure a fresher product with a longer shelf life.

Lemon Myrtle –
A Research Summary of Health and Functional Benefits

PREPARED BY LISA YATES, ADVANCED ACCREDITED PRACTISING DIETITIAN

Lemon myrtle is a beautiful native Australian plant that grows in the subtropical rainforests of the coastal hinterlands of central and southeastern Queensland. The scientific research conducted on lemon myrtle to date is fascinating and suggests there are many exciting research opportunities ahead to discover the full potential of this Australian native plant.

Lemon myrtle is well-known for its strong scent, which is often described as a blend of lemon, lime and lemongrass. Lemon myrtle leaves can be dried and turned into a powder or distilled to produce an essential oil, both of which can be used across a wide range of applications. Its by-products can also be harnessed to create a hydrosol 'floral water' and microfibre material.

It does not contain caffeine, making it an ideal ingredient for herbal infusions and tea blends. It also provides a distinctively clean and crisp citrus flavour for a range of cooking uses including glazes, cakes, biscuits, dressings, mayonnaise, sauces and ice creams.

The essential oil is used in cosmetics, diffusers and aromatherapy, and is a popular botanical in gin. Lemon myrtle hydrosol (the aromatic water produced during the distilling process) is used to create fragrances and room sprays, and its microfibre can be made into cosmetic scrubs and hand creams.

Recently, there has been great interest in lemon myrtle's natural antibacterial, antimicrobial and antifungal properties, and there is a growing body of scientific evidence backing these beneficial functions. As a result, lemon myrtle is also a much sought-after ingredient for household cleaning products, disinfectants and hand sanitisers.

This report is a summary of the key research evidence behind the many functional and health benefits of this fascinating Australian native plant, grown sustainably and locally in northeastern Australia.

As an Advanced Accredited Practising Dietitian, I'm pleased to share this research summary, highlighting the current research on the nutrition and health benefits of lemon myrtle. While there is more to learn about lemon myrtle and research is only just beginning, there is already strong evidence that Australians have much to gain from this unique native Australian botanical.

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Fragrance & Flavour

The flavour and aroma of lemon myrtle has been the subject of numerous studies.[5, 6, 7] The aroma has been described as that of a lemon lolly perfumed with menthol notes.

The flavour is of strong lemon with some sweetness and cooling on the palate, with refreshing intense citrus notes. In layman's terms, lemon myrtle has been described as 'lemonier than lemon'.

> "A distinctive aromatic lemon fragrance."

Lemon myrtle aroma

The main source of the sweet citrus scent of lemon myrtle essential oil are the natural compounds citral, citronellal and linalool.[8] It is citral that also gives lemons, lemongrass and lemon verbena their lemony aromatic quality.

The non-lemon citrus aromas in lemon myrtle are mainly due to other organic compounds such as alpha-pinene, eucalyptol and aromadendrene-allo.[5]

The refreshing sweet citrus aroma of lemon myrtle essential oil in a diffuser may help reduce stress and induce relaxation. This has been found with other citrus scents that include:

- A Korean study which found aromatherapy with citrus scents, combined with music, reduced stress in Korean nursing students ($p = 0.012$).[9] Similarly, a Taiwanese study found citrus scents and music also caused relaxation in a group of healthy adults ($p = 0.003$),[10] while a third study found the aroma of citrus significantly reduced heart rate ($p = 0.046$), stress and anxiety scores ($p = 0.014$) in a group of Japanese women.[11]
- Another Japanese research team[12] found a citrus scent enabled 12 depressed patients to have markedly reduced doses of medication for treating their depression. It was found the citrus fragrance helped normalise neuroendocrine hormone levels and improved their immune function. An earlier mouse study by the same researchers found similar results.[13]
- A study of 50 women in the US aged 23–70 also found just 15 minutes of exposure to a citrus scent essential oil improved their positive feelings by 17% compared with a control group, although the improvement in all positive feelings was not statistically significant ($p = 0.15$). Feeling more "proud" and "active" ($p = 0.07$) and less "nervous" ($p = 0.06$).[14]
- An Austrian study investigated the impacts of orange and lavender essential oils on anxiety, mood, alertness and calmness in 200 patients (aged 18-77 years, half women, half men) waiting for dental treatment in a dental practice. They were divided into two groups – one with orange another with lavender compared to a control group with no scents. Both the orange and lavender scents reduced anxiety and improved mood in patients waiting for dental treatment compared to those without scents.[15]

Lemon myrtle flavour

A range of studies have been conducted on the flavour of lemon myrtle in food products in the past which have produced varying results.

Product development analyses in 2002 found consumers consider lemon myrtle flavoured sorbet acceptable and desirable, and the incorporation of less sugar and/or higher amounts of citric acid was found likely to increase acceptability even further.[5]

Unfortunately, however, when it comes to incorporating lemon myrtle essential oil into food products, researchers have found it tends to lose its unique flavour characteristics in products such as carbonated beverages, mustards and mayonnaises over time.[5] However, a potential way to prevent this loss of flavour has been identified.

Researchers have demonstrated the inclusion of selected gums (such as sodium alginate), regulation of pH levels at 3.5, and using microencapsulation (a food manufacturing process that stabilises oil in food products) could all help preserve the fresh flavour of lemon myrtle in these foods and beverages.[5] Microencapsulation also boosts its antimicrobial effect and so may influence lemon myrtle's use as a food preservative.[17, 18]

When it comes to herbal drinks, lemon myrtle appears to be more attractive than the highly popular green tea. Australian researchers conducted a series of sensory studies[19] and found the study volunteers preferred the appearance and colour of lemon myrtle tea compared to green tea. The ratings for flavour and taste, and the overall acceptability score, were also higher for Australian herbal lemon myrtle tea compared with green tea.

> "Strong lemon flavour with some sweetness and cooling on the palate, with refreshing intense citrus notes."

It seems likely that the higher scores for lemon myrtle tea over green tea could be related to the presence of other volatile components and reduced 'bitterness' due to the absence of caffeine in lemon myrtle.[19]

This hypothesis is backed up by previous research showing that the quality and consumer acceptability of tea are both affected by the content of catechins, caffeine, amino acids, theaflavones, and other volatile components in tea.[20]

- Lemon myrtle leaves contain the highest amount of citral (>90%) of all known lemon herbs, and its flavour and aroma have been described as 'lemonier than lemon'.[8]
- Lemon myrtle essential oil can be added to room diffusers to freshen a room, and may relieve stress,[9] and also repel insects as both citral and citronellal are common fragrances used for insect repellent.[16]
- An Austrian study in dental practice found orange and lavender scents significantly reduced anxiety and improved mood in patients waiting for dental treatment.[15]

Uses & Applications

Lemon myrtle does not contain caffeine, making it ideal for use in herbal infusions and tea blends. It is commonly used to add a clean and crisp citrus-like flavour to a wide range of cooking applications such as glazes, cakes, biscuits, dressings, mayonnaise, sauces and ice creams.

The oil is used in diffusers and aromatherapy, while the dried leaf is used to flavour gin. Lemon myrtle hydrosol (aromatic water produced in the distilling process) is used in fragrances and room sprays, and microfibre created from the plant's stems is used in cosmetic scrubs and body wash.

Interest in lemon myrtle's natural antibacterial, antimicrobial and antifungal properties is increasing and there is a growing body of scientific evidence backing these beneficial functions. As a result, lemon myrtle is increasingly sought-after as an ingredient in a range of household cleaning products, disinfectants and hand sanitisers.

AUSTRALIAN QUALITY CONTROL

New rapid technologies[21, 22] are discovering the unique chemical signature of Australian lemon myrtle, which will help determine if lemon myrtle products are indeed lemon myrtle or adulterated with other lemon-scented plant products.

Australian Standards now exist to ensure lemon myrtle essential oil contains a minimum of 85% citral.[23, 24]

The main components of lemon myrtle that have been analysed and tested are:

- **Lemon myrtle essential oil**
  Produced by steam distillation from the crushed leaves and stems. The remaining residue also contains citral - the main active component - and other antioxidants. In general, 100grams of lemon myrtle leaf yields 1-4% of essential oil and 90-98% of this is citral.[8]
- **Lemon myrtle tea infusion**
  A tea is made from dried leaves steeped in boiling water and removed and then a sample (of either tea leaves or liquid) extracted for study.
- **Lemon myrtle ground/powdered dried leaf**
  From dried leaf, solvent extracts can be taken for study. Solvents include methanol, alcohol, hexane and water – each with varying results.

"Increasingly sought-after as an ingredient in a range of household cleaning products, disinfectants and hand sanitisers."

Lemon myrtle can be processed in a number of formats:

Dried leaves

Dried powder

Hydrosol

Essential oil

Microfibre

Extracts

Lemon myrtle is used in a wide range of applications:

Beverages:
Herbal infusion, tea and gin

FOODS:
Glaze, cake, biscuits, dressing, mayonnaise, sauce, ice cream and spice rubs

AROMATHERAPY:
Fragrances, diffusers and room sprays

COSMETICS:
Scrubs, body moisturisers, hand creams, shampoo, lip balm, body wash and perfumes

HOUSEHOLD PRODUCTS:
Disinfectant, hand sanitiser, hand soap and dishwashing powder

Health & Functional Benefits

Research into the health and functional benefits of lemon myrtle has been conducted using a wide range of different extracts and product forms of the native botanical over many years. The key active compound, citral, has also frequently been isolated and tested for its benefits.

However, even though lemon myrtle has long been used and accepted as an effective traditional bush medicine, drink and food flavouring by Indigenous Australians[25], methodical scientific investigation through human clinical trials to prove health benefits is in its infancy.

The majority of the scientific research undertaken has involved benchtop studies in the laboratory and studies using animal models. For this reason, the strongest evidence to date concerns the botanical's antimicrobial and antibacterial properties.

The key health and functional benefits of lemon myrtle, explored in the scientific literature, are summarised here.

DID YOU KNOW?

Lemon myrtle has a wide range of health and functional benefits of varying degrees including:

- Antibacterial
- Antiviral
- Antioxidant
- Antifungal
- Anti-cancerous
- Anti-inflammatory
- Metabolic health benefits

Antibacterial

The antibacterial properties of lemon myrtle essential oil were first studied in 1925.[2,3] Since that time, researchers worldwide have studied the antimicrobial properties of lemon myrtle essential oil and extracts, uncovering its key benefit as an antiseptic and surface disinfectant[26], and even as a possible food preservative.[17, 18]

These antimicrobial effects, on a wide range of bacteria[27], have led to lemon myrtle's inclusion in a number of personal and household cleaning products such as hand soap, sanitiser, shampoo, lip balm, dishwashing machine powder, and liquid disinfectant and cleaners.

DID YOU KNOW?

- Lemon myrtle can inhibit the growth of a wide range of bacteria including: *Staphylococcus aureus*, Methicillin-resistant *S. aureus, Propionibacterium acnes, Escherichia coli, Pseudomonas aeruginosa* and *Klebsiella pneumoniae*.[27]
- Lemon myrtle's essential oil has one of the highest levels of inhibition for methicillin-resistant *Staphylococcus aureus* (MRSA),[28, 29] a resistant bacteria commonly found in hospitals.
- Lemon myrtle essential oil was found to have strong antimicrobial activity against *Campylobacter jejuni* - a bacteria found in the intestines of chickens.[30]

Research into the effects of laboratory extracts has also found some interesting results. A team of Japanese researchers found herbal lemon myrtle was the most effective of 44 different types of herbal tea extracts for inhibiting an enzyme involved in the development of dental plaque on teeth, caused by the bacteria *Streptococcus mutans*.[31]

Another team, from Griffith University in Queensland, found methanolic extracts of lemon myrtle leaf inhibited 12 of 14 different bacteria strains.[32]

And a third study, from a team of researchers at the University of Queensland, demonstrated the antibacterial properties of a lemon myrtle extract against the following bacteria: *Staphylococcus aureus, Escherichia coli, Bacillus cereus, Proteus vulgaris, Pseudomonas aeruginosa, Enterobacter aerogenes, Acinetobacter baumannii, Shewanella putrefaciens* and *Listeria monocytogenes*.[17]

There is a volume of scientific literature showing the beneficial role of lemon myrtle extracts, however, the scientific world does not always deliver consistent results. Our literature review found some findings at variance with the many studies demonstrating a beneficial effect, and some studies failing to detect any effect at all. Much of this comes down to the way the lemon myrtle extracts are produced, and the solvents used.

One such study, conducted for the Australian Rural Industries Research and Development Corporation (RIRDC), found a methanol extract of dry ground lemon myrtle had a greater antimicrobial effect on 14 of 27 different food spoilage bacteria and yeasts than a water-based extraction method. Despite this positive effect, however, the same study showed no impact on *Staphylococcus aureus, Escherichia coli, Campylobacter jejuni, Salmonella enteritidis* and some forms of Candida yeast.[33]

This split finding is puzzling, and may be due to the particular strain of bacteria used or the methodology applied, and invites follow-up investigations. The research available right now is only the tip of the iceberg; there is much more to uncover about lemon myrtle.

> Researchers around the world have found lemon myrtle's antimicrobial properties make it a good antiseptic and disinfectant, and possibly even a useful food preservative.

Lemon myrtle essential oil contains 90% citral or higher,[27] and citral itself has antibacterial properties which have been known since 1949.[26, 27, 34, 35] For example, citral has antibacterial effects on MRSA resistant bacteria,[36] as does lemon myrtle essential oil.[27, 28, 29]

Antiviral

Research has shown lemon myrtle essential oil (applied topically as an ointment) is effective against *Molluscum contagiosum* - a common viral skin condition in childhood and a sexually transmitted disease in young adults.[37]

It has also been found that citral in lemongrass essential oil has antiviral properties against norovirus[38], herpes simplex 1 virus[39] and yellow fever virus[40]. Other lemon-scented essential oils that have also shown antiviral properties are:

- Lemongrass essential oil on norovirus[38,41]
- Lemon balm essential oil on avian influenza A virus (H9N2) and herpes simplex type 1 and 2.[42,43]

While these studies suggest it is possible citral sourced from lemon myrtle might have similar effects, it is impossible to draw any conclusions until further research is conducted.

In related research, a recent study in Brazil found citral can reduce fever in rats by acting on the biomarkers of inflammation which signal fever[44], which could be useful given fever is a key symptom of many viral illnesses.

Other research shows particular flavonoid compounds have direct antiviral activity in some viruses. A 2019 study looked at the impact of flavonoids on the Middle East Respiratory Syndrome-coronavirus (MERS-CoV) and found some could block the enzymatic activity of MERS-CoV 3CL protease enzyme which is necessary for a virus to replicate and grow.[45]

Interestingly, lemon myrtle contains kaempferol - a flavonol (a subclass of flavonoids). Kaempferol appears to block the mechanism allowing a virus to escape from a cell.[46] This preliminary research provides a new angle for investigation but does not yet answer a number of questions such as the dose required and the best format for effective delivery. It is therefore too early to suggest flavonoids like kaempferol might be a new form of antiviral.

Antifungal

There are a number of studies that demonstrate lemon myrtle essential oils might have a promising role as an antifungal treatment in a range of situations.

Lemon myrtle essential oil was found to be effective against two strains of fungi, *Candida albicans* and *Aspergillus niger*[27,47] which can cause severe infections in immunocompromised patients.[48]

"Lemon myrtle essential oils might have a promising role as an antifungal treatment"

Researchers from the Gosford Primary Industries Institute found lemon myrtle essential oil had a significant antifungal effect against *M. fructicola*, a common cause of brown rot in nectarines.[49] In similar work, a Brazilian study found lemon myrtle essential oil inhibited the production of the toxin ochratoxin A (OTA) which can spoil wine grapes.[50]

When it comes to laboratory extracts, Queensland researchers[17] found lemon myrtle extracts from dried powdered leaf have broad-spectrum antifungal activity against weak-acid resistant yeasts in comparison to the standard antifungal agents, fluconazole and amphotericin B.

Hexane extracts of lemon myrtle leaves have shown anti-yeast activity against *Candida albicans, Candida colliculosa, Candida lipolytica, Hanseniaspora uvarum, Pichia anomala, Pichia membranifaciens, Rhodotorula mucilaginosa* and *Schizosaccharomyces octosporus*.

Lemon myrtle extracts also possess the ability to inhibit the growth of food-spoilage yeasts that are resistant to organic weak-acids, suggesting potential application in food and beverage industries as an alternative to synthetic antimicrobial agents.[17]

Anti-cancerous effect

Preliminary laboratory extract research has found lemon myrtle extracts from dried powdered leaf, while rich in polyphenol antioxidants, have potential anti-cancerous properties. However, human clinical trials are needed before any conclusions can be drawn.

Researchers from the CSIRO found lemon myrtle leaf extracts reduced the proliferation of colon, stomach, bladder and liver cancer cell lines in a test tube study. An increase in cell death (apoptosis) occurred after the herbal extract treatment.[52] Citral itself has also shown anti-cancerous effects. A brief review of the evidence found citral effects against human prostate cancer cells and small cell lung cancer cells.[53, 54]

- Australian researchers found an extract from lemon myrtle leaf inhibited 12 of 14 different bacteria strains tested.[32]
- A number of laboratory studies around the world have shown lemon myrtle essential oil and leaf extracts contain a number of phytochemicals with antioxidant, anti-inflammatory and analgesic[51] properties.
- Researchers from the CSIRO found lemon myrtle leaf extracts reduced the growth of colon, stomach, bladder and liver cancer cell lines in test tube experiments.[52]
- A Japanese research team found lemon myrtle inhibited an enzyme involved in the formation of dental plaque.[31]

Antioxidant and anti-inflammatory

Antioxidant effects

Lemon myrtle tea infusion contains more total polyphenol antioxidants than many other herbal teas, and has similar antioxidant properties to black tea, but less than green tea.[55] Lemon myrtle tea is an excellent caffeine-free alternative to black and green tea.

One research team found lemon myrtle tea extracts had the third-highest polyphenol antioxidant content of all 44 herbal tea extracts they studied.[31] Lemon myrtle essential oil also contains antioxidant monoterpenes (one of which is citral) and polyphenols.[56]

"An excellent caffeine-free alternative to black and green tea."

COMPARING A CUPPA

An Australian study by researchers at the University of Queensland[19] found that lemon myrtle tea infusion extracts contained less total phenolic antioxidants than green tea (131 mg GAE/g vs 170 mg GAE/g respectively).

According to the researchers, "the variation of total phenolic content in different tea leaves could be attributed to different species, quality of leaf, cultivars and agricultural conditions." Different analytical methodologies and extraction solvents may also have different affinities for the different phenolic compounds.

Green tea also showed the highest antioxidant and free radical scavenging activity compared to lemon myrtle (20.4 vs 33.7 DPPH radical scavenging activity IC50 value (µg/ml), where the lower the number, the more antioxidant activity.

"More total polyphenol antioxidants than many other herbal teas."

Researchers have identified a number of antioxidant polyphenol compounds in lemon myrtle dry ground tea leaves and extracts. These compounds contribute to its significant antioxidant and free radical scavenging ability.[17]

Some of the polyphenol antioxidants in lemon myrtle include:

- Catechin[19, 57]
- Chlorogenic acid[19]
- Epicatechin[19, 57]
- Ellagic acid[58, 59, 61]
- Gallic acid[19]
- Rhamnoside[58, 60, 61]
- Hesperitin pentoside[58, 60, 61]
- Hesperitin hexoside[58, 60, 61]
- Kaempferol[19, 57]
- Myricetin[19, 57, 58, 59, 61]
- Naringenin[57]
- Quercetin[19, 58, 59, 61]
- Vanilic acid[57]

The free radical scavenging activity of antioxidants is important for preventing the damaging role of free radicals in a range of diseases, including cancer. Determining 'DPPH free radical scavenging activity' is a widely accepted mechanism for screening the antioxidant activity of plant extracts (DPPH is an abbreviation for the organic chemical compound 2,2-diphenyl-1-picrylhydrazyl).

The following table (table 1, page 25) shows the range of total polyphenol antioxidant content in lemon myrtle products along with their antioxidant capacity and free radical scavenging activity. The total polyphenol content of lemon myrtle products ranges from 17 to 660mg GAE/g DW and extracts also show antioxidant capacity/ free radical scavenging. Results depend on the solvent used for extraction.

"Lemon myrtle essential oil also contains antioxidant monoterpenes (one of which is citral) and polyphenols."[56]

Table 1:

Antioxidant content and capacity of lemon myrtle products

Lemon myrtle form	Total polyphenol	Flavonoids	Total ORAC (antioxidant capacity)	DPPH radical scavenging activity
Lemon myrtle tea infusion liquid[59]	75.6mg GAE/g			
Lemon myrtle tea infusion extract[19]	131mg GAE/gDW			33.7 IC50µg/ml (less antiox capacity than green tea 20.4µg/ml)
Lemon myrtle freeze dried leaves[62]	74mg GAE/gDW	87mg CE/g DW		735-963(mM TE/g dw) increases with drying time
Lemon myrtle dry powder[58]	31mg GAEq/gDW		3360umol TEq/g DW	
Lemon myrtle methanol extract[17]	419mg GAE/gDW)			14.4 IC50µg/ml
Lemon myrtle ethanol extract[17]	373mg GAE/gDW)			14.3 IC50µg/ml
Lemon myrtle water extract[17]	281mg GAE/gDW)			31 IC50µg/ml
Lemon myrtle hexane extract[17]	17.5mg GAE/gDW)			1678 IC50µg/ml
Lemon myrtle ethanol extract[60]	119mg/g	15mg/g		61.45% with 100ug/ml conc 83.72% (leaf) and 84.46% (stem)
Lemon myrtle methanol extracts[33]	88mg GAE/L			56.6% (%DPPH measured as absorbance at 515 nm reduced)
Lemon myrtle dried powder methanol extract[61]	660mg GAE/g DW	134mg CatE.2/g DW)	4136 umol TE/g DW	
Lemon myrtle dried powder hexane extract[57]	266mg GAE/100g			88% (% radical scavenger activity by DPPH at 1000 µg/m)

FUTURE RESEARCH OPPORTUNITY – CITRAL AND THE GUT MICROBIOME

Does citral and other lemon myrtle antioxidants have positive effects on the gut microbiome? A 2019 Chinese study found that citral and other antioxidants from orange essential oil had positive effects on *lactobacillus* bacteria in the gut of mice - the mouse gut microbiome.[63] However, there is no human evidence to date to illustrate how lemon myrtle antioxidant compounds are absorbed into the body, nor how they are metabolised.

There is some evidence that flavonoids in general are metabolised by the gut microbiome and pre-clinical studies have shown how flavonoids modulate intestinal immune function.[45,63] However, this is an area of research that requires future investment.

Anti-inflammatory effects

Researchers from the CSIRO and UNSW[59] found lemon myrtle leaf extracts provide health benefits by suppressing the activity of enzymes involved in the body's inflammatory response. This caused a reduction in inflammatory markers in benchtop experiments, demonstrating these potential anti-inflammatory properties. However, human clinical trials will be required to determine if humans can benefit from these potential health benefits.

The citral compound, found in lemon myrtle leaf extracts, has also demonstrated anti-inflammatory and analgesic effects by reducing inflammation biomarkers.[51, 64, 65]

Metabolic health

Lemon myrtle extract researchers have also explored the impact of extracts on metabolic health. Researchers from Malaysia and La Trobe University in Melbourne recently discovered that lemon myrtle essential oil extract was more effective at inhibiting the enzyme alpha-amylase than a range of other plant-based essential oils they analysed in their study.[56]

This is important because alpha-amylase is required to break down and digest carbohydrates and therefore may help to control blood glucose levels – an important factor for people with diabetes and a range of other health concerns. The research team said this inhibition of alpha-amylase was related to the antioxidant activity of monoterpene compounds. Citral is a member of the monoterpene family.

> "The citral in lemon myrtle may itself be directly beneficial for metabolic health"

This finding is supported by another study which assessed a lemon myrtle extract from dried powdered leaf. A team from Australia's CSIRO found this extract inhibited the function of three enzymes in a test tube experiment. These particular enzymes - alpha-glucosidase and pancreatic lipase – are involved in carbohydrate and fat digestion. Whereas angiotensin converting enzyme is involved in blood pressure regulation by modifying the body's fluid volume.

The ability to change the actions of these enzymes may influence blood glucose, blood fats and blood pressure levels and the development of metabolic syndrome, however, human clinical trials are required to confirm these benchtop results.[61]

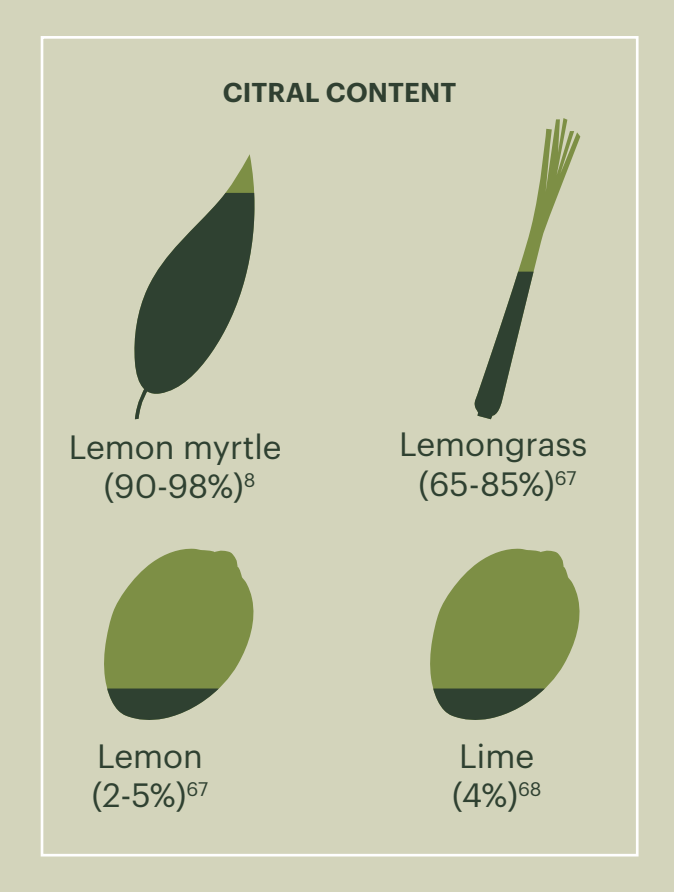
The citral in lemon myrtle may itself be directly beneficial for metabolic health due to its ability to inhibit and disrupt the metabolic processes leading to the growth and development of fat cells (adipogenesis).[66]

Nutrient Composition

The nutrient contribution of lemon myrtle can be quite variable and is largely dependent on the form of lemon myrtle that has been selected for testing and the methods of analysis. A number of nutrients and compounds are outlined below.

Citral

Citral was originally identified and isolated more than 100 years ago from the Australian native lemon myrtle plant.[8]



Citral gives lemon myrtle, as well as lemons, lemongrass and lemon verbena, their lemony aromatic quality. However, Australian researchers have found lemon myrtle is a richer source of citral than essential oils from other similar herbs including lemongrass or May Chang (*Litsea cubiba*).[8]

The citral content of lemon myrtle is remarkably consistent regardless of whether it has been extracted from leaves that are new, mature, fresh or dried.[8] Lemon myrtle leaves generally yield around 1-4% oil and, of this oil, around 90-98% is citral.

There are two forms of citral: citral a (neral) and citral b (geranial). On average, the balance of each in lemon myrtle is around 38.7% neral and 52.5% geranial.[8, 21] Lemon myrtle essential oil also contains another 24 aldehydes (organic compounds contributing to total citral which can provide scent) including myrcene, limonene, citronellal and linalool, among others.[8]

Other studies have identified the presence of other minor forms of citral including iso-citrals and iso-geraniols[69], and a recent Australian scoping study found lemon myrtle tea infusion contains citral (both A and B varieties) at around 33mg/g of dried leaf.[70]

The US Food and Drug Administration has established an allowable daily intake (ADI) value of 0.5mg/kg for citral.[27]

Nutrient composition of lemon myrtle preparations

A number of different sources for the nutrient composition of dried ground lemon myrtle leaf have been identified and listed in Table 2 (page 30). Australian Native Products also commissioned a compositional analysis of dried lemon myrtle leaf (May 2020). It is easy to see lemon myrtle dried ground leaf contains a number of nutrients in small amounts. However. a typical serving size for lemon myrtle as a flavouring agent would be small (1-2g) and hence will only provide trace amounts of nutrients to the diet.

"Citral was originally identified and isolated more than 100 years ago from the Australian native lemon myrtle plant."[8]

Table 2:

Nutrient composition of lemon myrtle dried ground leaf from various sources

Nutrient (units)	NMI May 2020 analysis per 100g (per 1g)[71]	FSANZ Nutrition Panel Calculator database 2011[72] Per 100g (per 1g)	RIRDC Report[19]	RIRDC Report[58]
Energy (kJ)	500 (5)	683 (6.8)		
Protein (g)	8.2 (0.082) (crude protein)	8.3 (0.083)		
Total fat (g)	4.7 (0.047)	1.8 (0.018)		
Saturated fat (g)		0.5 (0.005)		
Carbohydrates (g)	8 (0.08)	1.8 (0.018)		
Total sugars (g)		1.8 (0.018)		
Insoluble fibre (g)	41 (0.4)			
Sodium (mg)	24 (0.24)	33 (0.33)		19 (0.19)
Boron (mg)	3.4 (0.034)			
Calcium (mg)	1700 (17)		1500 (15)	1583 (15.8)
Chromium (mg)	<0.2 (LOR)			
Copper (mg)	0.92 (0.0092)			0.47 (0.0047)
Iron (mg)	8.5 (0.085)		16.8 (0.168)	5.8 (0.058)
Magnesium (mg)	150 (1.5)		188 (1.88)	188 (1.88)
Manganese (mg)	1.6 (0.016)			1.28 (0.0128)
Molybdenum (ug)	<0.05 (LOR)			5.5 (0.055)
Phosphorus (mg)	130 (1.3)			114 (1.14)
Potassium (mg)	1100 (11)		958 (9.58)	1260 (12.6)
Selenium (ug)	<0.05 (LOR)			ND
Zinc (mg)	0.9 (0.009)		1.27 (0.0127)	1.06 (0.0106)
Lutein (mg)				6.6 (0.066)
Alpha carotene (ug)	<5 (LOR)			
Beta carotene (ug)	2100 (21)			ND
Anthocyanin (mg/g DW)				ND
Vitamin A (ug)				ND
Thiamin (B1) (mg)	<0.02 (LOR)			
Riboflavin (B2) (mg)	0.03 (0.0003)			
Niacin (B3) (mg)	1.1 (0.011)			
Pantothenic acid (B5) (mg)	0.27 (0.0027)			
Pyridoxine (B6) (mg)	<0.02 (LOR)			
Cobalamin (B12) (ug)	<5 (LOR)			
Biotin (ug)	7.3 (0.073)			
Folic acid (ug)	<5 (LOR)			
Vitamin C (mg)	7.2 (0.072)			ND
Vitamin D2 (ergocalciferol) (ug)	1.3 (0.013)			
Vitamin E (alpha tocopherol only) (mg)	65 (0.65)			
Vitamin E (total) (mg)				21.2 (0.21)
Vitamin K1 (ug)	1000 (10)			

Table 2 Notes: ND = Not detected, LOR = Limit of Reporting, Nutrition information is provided per 100g for easy comparison however the actual serving size is far less as a flavouring agent ie 1-2g, and hence will provide trace amounts of nutrients to the diet.

Drying methods impact lemon myrtle compounds

The method used to dry lemon myrtle leaves can significantly affect the retention of total phenolic content (TPC), total flavonoids (TFC), proanthocyanidins, gallic acid, hesperetin, as well as the antioxidant properties in the leaf extract.[61]

Australian and Bengali researchers discovered the optimal methods for a range of different leaf drying options, and describe the optimum conditions for hot air drying, vacuum drying, microwave drying, sun drying, shade drying and freeze drying.[61]

They also noted freeze-dried leaves contained the highest levels of a number of nutrients, and had the highest antioxidant capacity, compared with samples produced via other drying methods. They conclude there is no significant difference observed between all other drying methods and recommended microwave dehydration for industrial purposes due to its time and energy efficiency.[61]

> "Freeze-dried leaves contained the highest levels of a number of nutrients, and had the highest antioxidant capacity"

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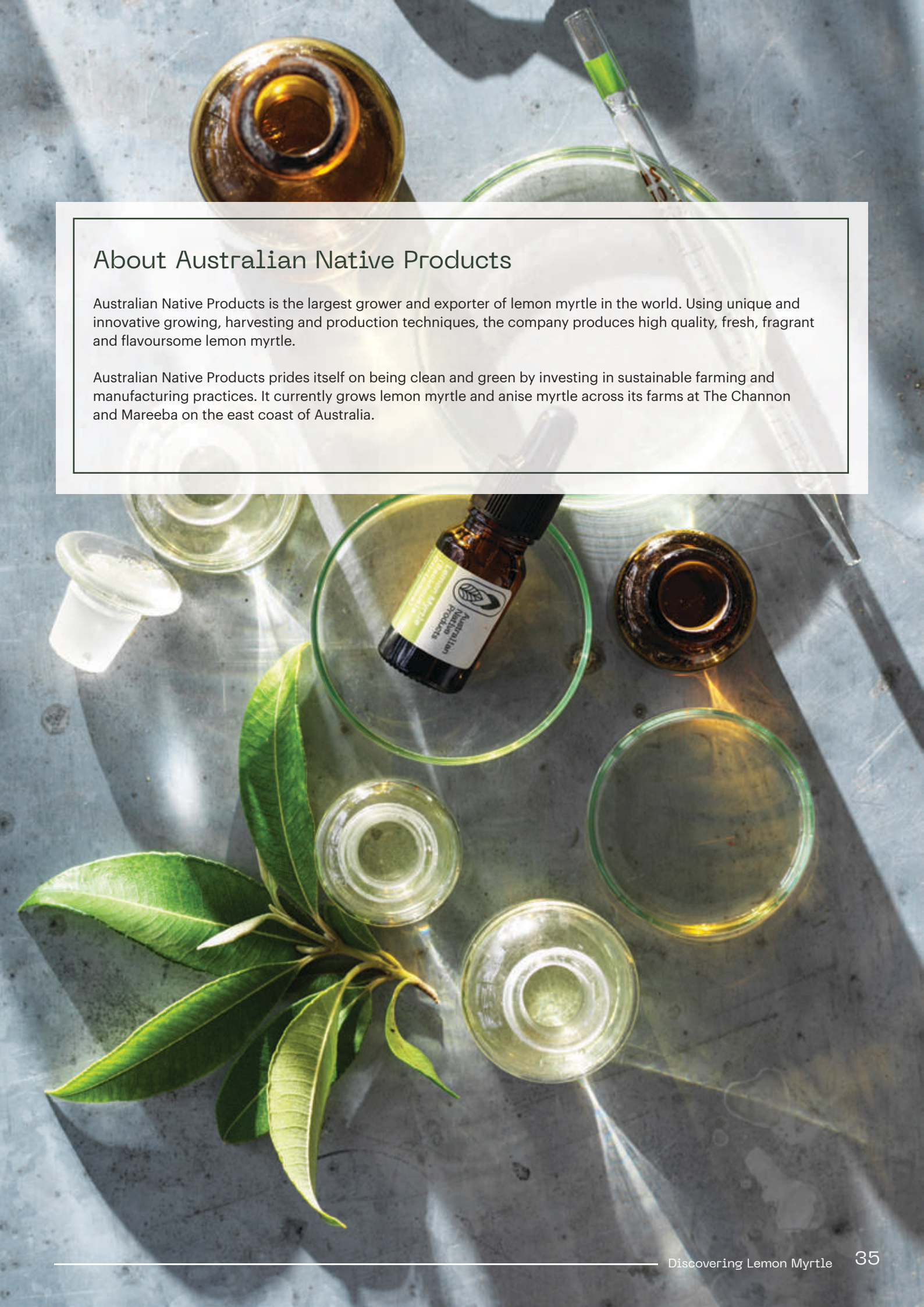
TABLES

Table 1: Antioxidant content and capacity of lemon myrtle products
Table 2: Nutrient composition of lemon myrtle dried ground leaf from various sources



About Australian Native Products

Australian Native Products is the largest grower and exporter of lemon myrtle in the world. Using unique and innovative growing, harvesting and production techniques, the company produces high quality, fresh, fragrant and flavoursome lemon myrtle.

Australian Native Products prides itself on being clean and green by investing in sustainable farming and manufacturing practices. It currently grows lemon myrtle and anise myrtle across its farms at The Channon and Mareeba on the east coast of Australia.

Australian Native Products

This project has been funded by Australian Native Products who pioneered the farming of Australian native botanicals in 1998 and is now the largest grower and exporter of lemon myrtle in the world.

This research summary of health and functional benefits has been written by Lisa Yates, Advanced Accredited Practising Dietitian, for educational purposes and should not be considered medical advice. Please see your health care provider for individualised medical advice if required. June 2020.