Branching Out Blueprint

Gin Botanicals

THE OPPORTUNITY FOR TARANAKI, NEW ZEALAND

venture TARANAKI
Te Puna Umanga

A blueprint for the future of food and fibre

Branching Out is a project that has been initiated and led by Venture Taranaki. It is underpinned by funding from the Ministry for Primary Industries' Sustainable Food and Fibre Futures fund (SFFF). It is supported by local sponsors as well as the region's three district councils – New Plymouth District Council, South Taranaki District Council and Stratford District Council. The project has identified a number of innovative, commercially viable food and fibre value chain opportunities for Taranaki. This work supports the region's strategy and long-term vision for a resilient, high-value, and low-emissions economy built on inclusivity and sustainability, as articulated by Tapaue Roa and Taranaki 2050 – the guiding strategic documents for the region, co-created with the people of Taranaki.

Branching Out aims to strengthen and diversify the Taranaki economy and has taken input from a wide range of industry participants, from landowners to interested growers, manufacturers to food & fibre entrepreneurs and potential investors. Through a process of investigation, a shortlist of eleven feasible ventures have been selected. Crown Research Institutes and universities, including Massey and Lincoln, were engaged to provide robust research that underpins each venture selection. Work has also been undertaken with commercial partners to support the development of prototypes with significant market potential, and a core focus on sustainability and waste reduction.

The investigations, collaborations, and potential commercial pilot opportunities for the region that have been explored as part of this project are being presented as Venture Blueprints. These blueprints aim to build investor confidence and serve as an informative and inspirational roadmap to kick-start complementary land-based activities and associated value chain enterprises in Taranaki.

The blueprints focus on traditional methods of assessing value, determined by comparing inputs (land, animals, machinery, time) and outputs (milk, meat, wool, other products). However, consumer expectations and an increased awareness of environmental degradation mean that thought should also be given to how the natural environment can be protected and what value this action can add to a developing sector.

TE TAIAO

In 2020, the Primary Sector Council released their Food and Fibre Strategy, Fit for a Better World. This strategy adopted the Te Taiao framework, acknowledging that Te Taiao is all of the natural world that contains and surrounds us (land, water, air, and biological life). It is a uniquely New Zealand perspective that is underpinned by three guiding principles:

- Our land, water, air, and biological life must be able to thrive without over-use
- Any use is a privilege, not a right
- If something is not healthy or well, we must fix it.

Developing or participating in a new value chain is an opportunity to consider your business's relationship with Te Taiao. It is a chance to farm, produce and engage in a way that safeguards the mana and integrity of the natural world. If the whenua (land), and the entities that are connected to it, are to be nourished and thrive, then it must be cared for and protected. Each blueprint opportunity should be considered with Te Taiao in mind.

DISCLAIMER

How to reference: Venture Taranaki – Branching Out, *Gin botanicals: The opportunity for Taranaki*, June 2022

venture TARANAKI Te Puna Umanga
Ministry for Primary Industries Manatū Ahu Matua
Te Kaunihera-ā-Rohe o Ngāmotu New Plymouth District Council
Te Kaunihera ō Taranaki ki Te Tonga South Taranaki District Council
TE KAUNIHERA Ā ROHE O WHAKAAHURANGI STRATFORD DISTRICT COUNCIL

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WHY GIN BOTANICALS?

- Botanicals are key ingredients used in gin production as well as a range of other products, such as nutraceuticals, cosmeceuticals, pharmaceutical products, essential oils and food and beverages.
- Currently most of the 'core' gin botanicals (juniper berries, orris root, liquorice root and angelica root) used by New Zealand gin producers are sourced from overseas. Growing these in New Zealand could shorten supply chains, create value for New Zealand growers and provide opportunity for the provenance, quality assurance and market differentiation that our gin industry is seeking.
- Gin botanicals are high value ingredients, that could provide good returns for small cultivations.
- New Zealand has the ability to grow a wide variety of gin botanicals well.
- Gin botanicals are a sustainable alternative – New Zealand-grown gin botanicals could be grown organically and create market interest here and overseas.

WHY NOW?

- The gin/spirits industry is in growth mode, both in New Zealand and overseas. As at February 2022, the New Zealand Institute of Economic Research report 134 spirits producers in New Zealand, with this sector growing year on year, and having increased threefold since 2015, with exports increasing also - valued at $45.8 million for the 2020 calendar year.[1]
- The New Zealand spirits industry is signalling increased interest in local sourcing, reducing reliance on overseas imports, and generation of unique propositions for product which is made from 100% New Zealand provenanced ingredients.[2]
- Accessing imported ingredients is increasingly challenging and expensive, and supply chain constraints (caused by COVID-19 related logistics and business bottlenecks, socio-political and climate change impacts, and specific issues such as a fungal disease *(Phytophtora austrocedri* impacting juniper trees in Europe) mean that New Zealand could have opportunity to grow for its own spirits industry and for export purposes also.
- Changing climate patterns and issues accessing water and land could see some countries struggle to grow traditional crops to meet rising market demand. New Zealand may be able to take advantage of this and provide alternative supply chains for existing and new buyers of botanicals.

WHY TARANAKI?

Taranaki has climate and soils suitable for the growth of high-value gin botanicals.

There are gin makers and other manufacturers in Taranaki (with strong industry connections beyond the region) who are keen to support local supply and the development of gin botanicals enterprise within the region.

There is an established community of botanicals growers already in Taranaki, with connections to experts and industry bodies who could be involved in, or support, the development of gin botanicals specialisation.

Early evidence suggests that gin botanicals grown locally are likely to have unique volatiles profiles and that 'terroir' effects may exist for these, providing opportunity for product differentiation.

Gin botanicals are a niche product which no other region within New Zealand has evolved to any degree as yet. Taranaki could lead in this area and in so doing align itself with a booming industry which has appeal for customers who might ordinarily align themselves with wine growing regions.

WHO SHOULD BE INTERESTED?

Existing Taranaki growers looking to expand their offering or connect with new supply chains.

Taranaki landowners (with limited available land) considering how best to diversify activities on their property.

Investors, manufacturers and entrepreneurs considering future trends and growth markets in the food and fibre sector.

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1 *NZ Institute of Economic Research: Alcohol Beverages industry: A thriving, durable industry adding value to New Zealand's financial, environmental and social economies. A report by NZIER to NZ Alcohol Beverages Council with additional information provided by NZABC's members (February 2022). Available at www.nzabc.org.nz*

2 *https://issuu.com/theintermediagroup/docs/the_shout_nz_may_2021 (pg 7)*

SECTOR TURNOVER AND GROWTH TARGETS

- **Domestic opportunity:** Currently valued at approximately **$2m**[3].
- **Existing spirits market: 134** spirits producers in New Zealand, with threefold increase since 2015[4].
- **Spirits market size:** Spirits exports estimated at **$45.8m** for the 2020 calendar year[5].
- **Other opportunities:** Orris is considered 'The World's Rarest Perfume Ingredient' and can be valued up to **€50,000** per kg[6].
- **Adjacent industry growth:** Some similarities to global medicinal plant industry which is expected to double in size between now and 2028 to be worth **USD$430b**[7].

IN-REGION INFRASTRUCTURE OPPORTUNITIES

There are currently no at-scale drying or processing facilities for gin botanicals in Taranaki, however these can be initially designed for small scale operations without need for significant capital investment. Over time and with enough demand from small or medium-sized growers, it is hoped that there may be an opportunity to construct or install drying and other value-add processing facilities in region.

VALUE ADDED OPPORTUNITIES

Each of these gin botanicals offers opportunity for considerable co-product development alongside the gin botanicals product focus. Later sections of this report highlight what some of these opportunities are in relation to each of the four botanicals.

There are considerable opportunities for R&D in relation to growing and processing of these botanicals – literature on which is scarce, and especially for the New Zealand context.

FINANCIAL RETURNS

Despite the significant presence of juniper berries, angelica root and orris root in gin, very little market information can be found on their financial performance, largely due to the difficulty in projecting the set-up costs, operational costs and timeframes before significant yields might be achieved from crops grown in New Zealand. The below table is a four-year gross margin for liquorice root, as prepared by The AgriBusiness Group.

Activity	$/ha
Revenue	252,000
Direct Establishment Costs	35,960
Annual Costs (x4)	13,320
Harvest Cost	6,695
Drying and Sales Cost	19,750
Net Return	176,275
Net Annual Return	**44,069**

The market potential for these botanicals is outlined in **Appendix A**, based on an internet search of commercial products that can be purchased in New Zealand. As expected, the value of the product increases as the raw material is processed.

TARANAKI BRANCHING OUT SCORECARD

Opportunity rating
1 = low, 5 = high.

This scorecard is intended to act as a quick comparison between blueprint opportunities. These scores are subjective and based on information available at the time of publishing. Further professional investment advice should still be sought.

Development Opportunity	
Suitable growing conditions in Taranaki	**4**
Suitable land available at reasonable cost	**4**
Existing investment interest	**3**
Local development experience	**3**
Circular economy opportunities	**4**
Established local, domestic, and international demand	**4**
Product Opportunity	
Large and growing demand for high quality gin botanicals	**4**
New Zealand gin botanicals and associated products differentiated in key markets	**3**
Contribution to health and wellness of the consumer (health product market)	**3**
Established sustainable/regenerative farming practices, including water usage	**4**
Reduced greenhouse gas emissions compared to existing land uses	**4**
Postharvest and Processing Opportunity	
Postharvest and processing facilities available now in Taranaki	**2**
Opportunities for development of added value products, particularly from waste products	**4**

3 *This figure is based on current purchasing prices and assumes that 50% of New Zealand's median sized distilleries (67 of 134) are making gin using similar volumes of juniper, angelica, orris and liquorice.*
4 *As outlined by NZ Institute of Economic Research (NZIER) report (2020)*
5 *NZIER report (2020)*
6 *As outlined in a 2018 BBC Travel documentary - https://www.bbc.com/travel/article/20181008-orris-the-worlds-rarest-perfume-ingredient*
7 *https://www.fortunebusinessinsights.com/herbal-medicine-market-106320*

Gin botanicals in New Zealand and internationally

HISTORY

In the process of making gin, there are key botanical ingredients which are used in most recipes; four of which are the focus of this blueprint: juniper berries, angelica root, orris root and liquorice root.

Gin is a distilled beverage, initially developed in northern Europe, which has several classes and formulations. The most popular is the London Dry method for distilling gin. This involves the redistillation of alcohol 96% (v/v) in the presence of juniper berries and other natural botanical ingredients such as angelica root, orris root, liquorice root, coriander seeds, cardamom seeds, calamus root, orange peel, lemon peel, anise seeds, and many others. All of these ingredients are rich in essential oils, which contribute to the aroma of most gins, but the main flavour of the distilled gin should come from the juniper berries.

Juniper berries are more rightly 'cones' of the 'common juniper' *(Juniperus communis L.*, referred to here as *J. communis)*, which is an evergreen shrub/tree of the Cypress family. Junipers are native to northern hemisphere countries throughout Europe, UK, America and Asia, with a range of growth formations that are influenced by ecological factors. There is a long tradition of juniper berries being wild harvested and no evidence to date of these being actively farmed as 'crops'. Bulk supplies for the gin industry are typically derived from Italy, Serbia, Macedonia and India.

Angelica *(Angelica archangelica L.)* root, also widely known as 'wild celery' is used in making gin as it holds key flavours and creates the nutty, sweet flavour. Thought to be originally from Nordic regions and commercially grown in the Northern Hemisphere, angelica root has a wide range of applications. It has been found growing in the wild in New Zealand since 1964 and has been more recently grown from seed for gin industry uses.

Orris root is derived from iris flower plants, and specifically can be derived from the *Iris pallida L.* plant, which is well established and widely available in New Zealand. It is an important ingredient in gin, being used to hold and fix other botanical flavours. Orris root plays an important role in both traditional indigenous and modern medicine applications, as well as being used in the food and beverage industry.

Liquorice root gives the liquorice flavour, as well as adding base and length to the gin, increasing its viscosity. Liquorice roots are known to have been cultivated as long ago as the 3rd century, with ancient Greeks and Romans using liquorice roots in medicines, and it has many commercial applications currently, including in traditional and modern medicines, and in food and beverage applications. The most common species being cultivated for commercial purposes is the *Glycyrrhiza glabra L.*, species. Trials in New Zealand (in Waikato, Canterbury, Otago and more recently in Taranaki) have shown it can be successfully grown here.

Angelica, orris, and liquorice roots are currently mostly imported from overseas to supply to gin producers and other retailers in New Zealand. The current supply chain exposes the New Zealand gin industry and other businesses to external risks such as supply chain issues, price fluctuations, and exchange rate risks, as well as inability to provide New Zealand (or in some cases *any*) provenance, or sustainability credentials for these ingredients. The current supply chain is long, with several intermediaries, which increases the prices of the botanicals and causes quality issues risk. Thus, the carbon footprint of the current supply chain is higher than for proposed locally grown botanicals. Although the current supply chain provides advantages, such as diversified sources and well-developed expertise in growing these botanicals, local supply chain could provide an added value component for gin producers, as consumers are demanding more sustainable products.

OTHER PRODUCTS AND USES

All of the above plants can be processed in a number of different ways and are used as ingredients in a wide range of products, beyond gin, such as:

- Supplements.
- Beauty products and 'cosmeceuticals' (e.g., skin creams).
- Pharmaceutical products (creams, balms, ointments, tablets, capsules).
- Essential oils.
- Food and beverage.
- Animal fodders and animal health treatments.
- Fresh and dried flowers.

WHY GIN BOTANICALS FOR TARANAKI

David and Jo James, of Begin Distilling (makers of Juno Gin) have been championing this as an opportunity for Taranaki and have invested themselves in considerable research to help progress this potential. They have been working with Massey University and others throughout New Zealand since pre-launch in 2017 and these collaborations have been making steady progress in terms of developing more understanding about these botanicals and the opportunity they represent.

Although all of the four botanicals which are a focus of this blueprint are known to be able to be grown here, New Zealand has never, to date, placed any significant focus on growing these botanicals commercially. This is now changing. With New Zealand's spirits industry growing significantly in recent years (134 spirits producers as at Feb 2022), this sector has increased threefold since 2015, and there is now growing interest in both sourcing and growing these ingredients locally.

Gin spirits are made by distillation from fermented juniper berries due to their distinct taste offered by their oil compositions. Other botanicals are very important also, however juniper is the required and key ingredient for gin making.

One of the key issues presented to New Zealand gin distillers is that the commercially available juniper berries for distillation are sourced from various countries throughout Europe, Asia, North Africa, and North America. This often leads to large variance between batches purchased from the same commercial supplier. This requires multiple preliminary tests to be run with every new batch of juniper obtained from overseas to obtain the unique taste crafted to each New Zealand gin, which can be wasteful in terms of both time and money.

It is a similar story for the other gin botanicals. For most angelica root, orris root and liquorice root supplies, supply chains are currently long, with several intermediaries, exposing our buyers to unprovenanced supply, quality issues, supply risks and rising prices.

Being able to achieve greater quality control over locally grown ingredients, and local provenance and green credentials for these, could allow gin makers to offer distinctive product, as well as to better manage for quality and for consistency.

Taranaki could be well-placed to build a gin botanicals industry given the drive and vision of our local gin producers. The success of this industry would be underpinned by our suitable climate and rich natural soils, as well as the skills and reputation of various research institutes, universities and R&D providers who specialise in agricultural and food sciences with whom we have relationships already. The opportunity to further diversify use of these botanicals into other food and beverage opportunities, and pharmaceutical and cosmeceutical applications is also very promising.

NEW ZEALAND PRODUCT POINT OF DIFFERENCE

New Zealand has a strong international reputation of producing high-quality and unique products, such as, wine, lamb, merino, honey, kiwifruit and cheese. In the gin botanicals market, there is an opportunity to differentiate products created in Taranaki and New Zealand by developing a high-quality product, with highly transparent supply chains, underpinned by the New Zealand grown story and, increasingly, robust environmental credentials. It is becoming increasingly evidenced that plants grown in New Zealand have points of difference in terms of bioactive compounds expressed in them, likely a consequence of high levels of natural UV light in New Zealand. These points of difference, and accompanying unique flavour profiles, should allow companies the opportunity to carve out a niche for their product.

DRIVERS OF INDUSTRY GROWTH

In addition to growth in the spirits industry (both in New Zealand and globally), including that of premiumisation and the value placed by consumers on unique and exciting beverage experiences, there is a parallel movement happening in the food industry, with consumers interested in new flavours, new flavour combinations and in 'overseas experiences', both abroad and at home (the latter being a trend fuelled in part by COVID-19 travel restrictions).

Boutique and artisan beverages are being preferred over mainstream brands. There is also rising interest in non-alcoholic gin options and other alcoholic and non-alcoholic beverages, which 'gin botanicals' can also be an ingredient for.

The global demand for herbal medicines and their raw materials has been rising for many years and has been spurred on by COVID-19. The medicinal plant market was estimated to be approximately USD$185 billion in 2019 and is expected to reach USD$430 billion in 2028[8]. This projected growth is driven by a number of key factors including:

- The COVID-19 pandemic and lack of specific medicine for its treatment, increasing consumer focus on improving immunity and natural medicines.
- Increasing awareness and trust among customers about the associated health benefits, closely linked to the increasing evidence supporting the health claims of various products.
- Increased opportunities for inclusion of medicinal plants in the food, nutraceuticals and cosmeceutical industries.

8 https://www.fortunebusinessinsights.com/herbal-medicine-market-106320

VALUE CHAIN

There are not currently value chains, as such, in New Zealand for locally-grown botanicals. Because we currently import these, the botanicals value chains are predominantly overseas; these include growers, processors, manufacturers, marketers, wholesalers and international brokers, importers, distributors and wholesalers and retailers (with transport and other export-related services also).

If this value chain were to reside predominantly within New Zealand, instead of overseas, this could generate value for our own businesses and new jobs in relation this new enterprise.

Some information regarding Growers, Wholesalers/ Processors and Retailers follows.

Growers

Juniper is generally wild-harvested and the majority of the angelica, orris, and liquorice root growers in the Northern Hemisphere are small-scale family operations, operated as a secondary income. For example, orris roots are grown in between grape vines and olive trees in small private family farms in Tuscany (Webb James, 2013). Most of these operations have acquired specialized cultivation knowledge and skills in relation to these botanicals, which reflects in the high quality of roots that they produce. Post-harvest activities such as washing, drying, and maturing of the botanical roots also contributes to the value-add component of them. The quality of the angelica, orris, and liquorice roots plays a crucial component in determining the value of these. Therefore, knowledge and skills in the cultivation and post-harvest activities of the three botanicals plays a key role in establishing the value of these botanicals.

Wholesalers/Processors

The role of wholesalers is mainly B2B (business-to-business). Wholesalers such as UK-based Beacon Commodities add further value to the raw ingredients through processing, packaging, marketing, and distribution activities. Processing includes cutting, milling, extraction of oil and liquid extracts. These processes are crucial to enable a variety of applications in industries such as cosmetics, gin, and pharmaceutical. Packaging of the processed ingredients involves preserving the quality and safety of the products and provides accessibility to small to large size customers (e.g. small gin makers and large FMCG companies). This marketing activity can provide value to customers through quality assurance and product information.

Retailers

Retailers are the intermediaries that interact directly with consumers, as they are the B2C (business-to-consumer) intermediaries. Retailers such as pharmaceuticals, FMCG, and beverage derive value from producing further value-added products from the three botanicals. As an example, pharmaceutical company, Douglas Pharmaceuticals, uses angelica powder to produce its Clinicians "Bladder Confidence Formula".

FOOD MANUFACTURING AND EXPORTING REQUIREMENTS

Growing botanicals for use in food contexts or for export will require growers/processors to ascertain whether their growing for such end uses means they need to meet the requirements of the New Zealand Food Act and be compliant with any of the related National Programmes or a Food Control Plan.

Links below to overview information about the Food Act 2014, National Programmes and Food Control Plans:

Food Act 2014: https://www.mpi.govt.nz/food-business/food-act-2014/.

National Programmes: https://www.mpi.govt.nz/dmsdocument/10691/direct.

Food Control Plans: https://www.mpi.govt.nz/food-business/running-a-food-business/food-control-plans/.

Different countries have different market access requirements, and these need to be understood if exporting is envisaged.

For example, European Union (EU) market access requirements: https://www.cbi.eu/market-information/natural-ingredients-health-products/buyer-requirements#what-are-the-mandatory-requirements.

Australia market access requirements: https://www.agriculture.gov.au/import/goods/plant-products/importing-plant-products-for-human-consumption#dried-herbs-and-spices.

There are many consultancies and advisors who can assist with designing businesses appropriately for food processing and exporting businesses.

The medicinal plant industry in New Zealand is still in its infancy, however Natural Health Products NZ is a national industry organisation representing the natural products, functional foods, complementary medicines, cosmeceuticals, and nutraceuticals industries in New Zealand. They were established in 2002 by industry with support from New Zealand Trade and Enterprise and now this association provides helpful information and support to around 80% of all companies involved in New Zealand's natural product industry, including all major brands and manufacturers who are members of the association.

SHARED DRYING FACILITY

There is currently no drying or processing facilities for medicinal plants in Taranaki. Over time and with enough demand from small or medium-sized growers, it is hoped that there may be an opportunity to construct or install drying, and other value-add processing facilities in region. A drying facility is necessary to convert raw material (roots and other plant material) into high-value products.

Initial feasibility of drying equipment indicate that the cost of purchase starts at $115,000 (+ GST), with trolleys/trays starting at $15,000 (+ GST). This size of dryer would be capable of drying up to 450kg of roots at once, taking approximately 24 – 48 hours to fully dry. This cost would not be prohibitive if it were a shared asset by a collective of small local growers, as suggested by the Stratford Herb Society for the medicinal plants industry. Further consideration should also be given to the supporting facilities and processes required to operate the dryer, such as a building and post-drying packaging equipment.

GENERAL GROWING CONDITIONS

Taranaki's growing conditions are such at that it is often said that 'you can grow almost anything in Taranaki'. One of the earliest marketing slogans devised for the region was: 'Taranaki – Garden of New Zealand.' This phrase captures the Taranaki region's fortuitous mix of temperate climate, rich volcanic soil and bountiful rainfall, which contribute to a landscape that has the potential to support a range of horticultural endeavours. (Venture Taranaki, The Potential for Horticultural Development in Taranaki, 2014). Recently there has been considerable publicity regarding Taranaki achieving the highest number of sunshine hours in the country in 2021, and Taranaki has often been within the top few contenders for this title.

As a general summary of these conditions, according to Chappell (2014), Taranaki has a temperate climate with prevailing north-westerly winds bringing warmer air from the Tasman Sea. It experiences over 2,000 sunshine hours annually, with reduced sunshine hours on the hill country areas due to the high elevation which results in cloud formation.

Temperatures around Taranaki are between 20°C-22°C in Summer with a mean annual temperature of 13.5°C. However, Venture Taranaki's land and climate report suggests that Taranaki would be extremely lucky to hit 19 degrees Celsius as a summer average.[9]

The southern part of the region typically receives less than 1,500mm of rainfall per year, whereas the northern part receives over 2,000mm of rain.

Different areas of the region experience different wind speeds and direction due to the topography of the region. In the west, an average annual wind speed of 18.9 km/hr is experienced annually. However, the eastern part of Taranaki experiences lower average wind speed of 15.3km/hr annually due to the mountain acting as a wind shelter.

The region is well known for its volcanic history which has produced fertile soils. Taranaki's allophanic soils are free draining due to the mixture of black loam and clay soils. Taranaki soils have pH values of 5.7 to 6.5 which are acidic due to the volcanic origins (Burgess & Davies, 1951). Taranaki soils have also been known for their high phosphate retention ability, with free draining and compaction resistance qualities.

All of the above factors position Taranaki well as a general growing context for the identified gin botanicals.

9 https://www.venture.org.nz/assets/Uploads/Taranaki-Land-Climate-Report-Nov-2020.pdf

Assessing the options – which botanical might you grow?

JUNIPER

Juniperus communis **(Common juniper)**

Profile

Juniperus is a diverse genus of the *Cuppressaceae* (Cypress tree family) and is comprised of around 75 species.

Juniperus are also further subdivided into the Northern group, *J. communis*, which produces blue-black mature cones (commonly, and within this document, referred to as 'berries'), and the Mediterranean group *J. oxycedrus* allies, which produce reddish mature cones.

Juniperus are relatively slow-growing and are long-lived. There is evidence of *J. communis* growing to some 100-200 years in the UK, and trees estimated as old as 600 years have been noted.

J.communis can grow as a chamaephyte (prostrate mat-like growth), or a phanerophyte (upright growth), be bushy, columnar or spreading, and have branches/ branchlets that tend upwards, or droop downwards.

J. communis have separate male and female plants. The presence of both is needed in order for females to generate berries, in ratios of around 1 male to 8 females. Berries will only form and ripen adequately if a male juniper (or, alternatively, conifer) is within close proximity. However, seed fertility, and the ability to reproduce *J. communis* seedlings is adversely impacted if there are no male *J. communis* in the vicinity of the female trees.

Once mature, the *J.communis* plant will produce berries, or berry-like cones, which mature within three years from an unripe green colour to a deep ripe colour between blue and purple, often appearing black. The berries and other plant organs contain essential oils which have a characteristic aromatic flavour and taste, which have been utilised (primarily deriving from the berries) in the pharmaceutical and food industries, and also perfumery and cosmetic industries.

Berries of some juniper species are toxic, and consumption is inadvisable, however at least one author *(Mills, 2017)* believes berries from *J. chinensis* and *J. horizontalis* are edible, in addition to those from *J. communis* trees.

Christman (2004), states if the berries are for gin distillation then *J. communis* is the only option.

It may take further research to find more authoritative information regarding the edible nature of the full range of berries, but one clue is that the ISO standard (ISO - ISO 7377:1984) relating to juniper berries relates specifically, and only, to *J. communis* berries.

Benefits and uses

Juniper berries are the major, and key, ingredient in gin manufacture (the name 'gin' in fact derives from the Latin 'Juniperus' and other European variations of this word (e.g. genever, genevre, jenever).

Whole berries are incorporated into the gin distillation process and food industry, however extracted oils, or subcategories of these oils are generally incorporated into other manufactures.

The average yield of essential oils from ripe berry matter is generally between 0.5 – 3.0%. Oil composition and yield vary largely between different *J. communis* plants and has been found to be highly dependent on a range of factors including geographical location, the degree of ripeness, the age of the plant and berry, as well as a range of meteorological conditions such as temperature, length of sunlight and duration of photoperiod. The unique profiles of individual berries from different locations is achieved with respect to the varying ratios of a range of different compounds (30 - 120 or more) present in varying amounts.

Each location grows berries with slight differences in the compounds present, which can be referred to as "finger-print compounds". These influence the aroma of the berries. Berries produced in different regions of the same country even have largely varying quantities of each common component, and often have unique finger-print compounds, despite being grown in similar geographical locations. This is equivalent to the "terroir" effect found in relation to the same grape variety grown in varying locations.

The major constituents of juniper berry oils are monoterpenes (generally comprising a-pinene, sabinene, myrcene) sesquiterpenes (generally comprising caryophyllene, muurolenes, germacrene D and B, and humulene) and oxygenated terpenoids (generally comprising terpinen-4-ol and citronellol). Generally, between 80 – 96% of all compounds present for gas chromatography coupled with mass spectroscopy (GC/MS) analysis are confidently identified.

The major oils present in overseas juniper berries are generally noted as αPinene, βMyrcene and germacrene D, although there has been variation noted in predominant oils, that also highlight significant presence of Limonene, Terpin4-ol and Sabinene in some samples.

Massey researchers have found some preliminary evidence that New Zealand-grown juniper berry volatiles may exhibit some differences from European and Asian berries in terms of the predominant terpenes. However, with such small samples of New Zealand-grown berries as are currently available, work will be ongoing before there can be confidence around this.

The other plant organs the aromatic essential oils can be found in include the bark, the leaves (needles), sprouts, branches, and bark, however volatiles are present in differing, and generally lesser amounts in these organs.

Juniperus thurifera's ability to sequester carbon has been analysed *(Charro, Moyano & Cabezon, 2017, cited in Sneddon)*. While not *J. communis*-specific, it may be assumed that *J. communis* might follow a similar pattern. *J. thurifera* was found to not consist of a large amount of carbon, however its organic matter was found to have greater stability than either oak or pine forest organic matter. With organic matter stability and a long lifespan, it may be relatively safe to assume that *J. communis* will be able to sequester highly stable carbon over a long period.

Market profile and Financial Assessment

- We have not been able to find any information regarding the size of the market globally for juniper, however, based on the assumptions outlined in the Snapshot (Existing Spirits Market) we estimate that 50% of New Zealand's median sized distilleries (67 of 134) may currently be using around 30 tonnes per annum.
- The 'going rate' that New Zealand gin makers are paying in 2021-2022 for imported juniper berries is in the realms of around $22,000 per tonne, implying that they may be currently spending around $660,000 on imported juniper berries.
- It is currently difficult to project the set-up costs, operational costs and timeframes before significant berry yields might be achieved from trees grown in New Zealand. It may be some years before this is fully understood.
- Northern Hemisphere trees have been noted as producing only around 500gm – 1kg of ripe berries in a season. If this is borne out by the New Zealand experience, it might make the financials less attractive. However, innovations around plant breeding, cultivation and harvesting could help to boost production. It could still be a very attractive proposition for junipers to be planted to benefit land not wanted for annual cultivation, or grazing, with the eventual cropping providing a return on that investment in trees.
- It is envisaged that New Zealand-grown juniper might also serve well to supply Australian and other southern hemisphere gin manufacture. It may also prove worthwhile in the event that traditional northern hemisphere sources of juniper become compromised by climate change, disease and/or politics, and also as a distinctive ingredient for overseas manufacturers, especially if New Zealand juniper volatiles exhibit world-unique characteristics.

Cultivation, Harvesting and Processing

Information available re cropping in NZ	*J.communis* is not known to be cultivated as a crop anywhere, so it is difficult to find information relevant to cropping of same, however it grows wild in many Northern Hemisphere countries, and is grown successfully as an ornamental plant in New Zealand.
Climate	Known to grow in a variety of climates. Is tolerant of drought and cold and is capable of surviving with as few as 150 Growing Degree Days (GDD). However juvenile plants are susceptible to frost, and berries need access to warmth and light for ripening.
Soil	Known to grow in a range of soil types, including sand dunes, granite, limestone, sandstone, mountains, deserts, and bogs, as well as in pastoral landscapes. At least one writer notes that *J. communis* prefers free-draining soils. Is known to tolerate and grow on a wide variety of soil pHs.
Planting	The space requirement for *J. communis* is fairly significant. It is recommended that there needs to be one male ('non-productive') tree for around every eight female trees. The width of the (adult) trees themselves ranges from around 2.4m to 3.6m and spacing of trees should take this into account, as well as space between trees (especially so as to allow for sunlight and aeration, which are helpful for berry ripening, as well as for decreasing the inductiveness of fungal infections (rusts) and the effects of pests (e.g. Cypress Mealy Bug and Juniper Shield Bug in the Northern Hemisphere). Planting locations and placement of male (pollinator) trees should take into account prevailing wind direction, in order to maximise the potential for successful wind pollination. Sites should be flat to undulating, as this will provide best opportunity for mechanisation of harvesting. There are no 'off-the-shelf' solutions for this, but rather harvest-friendly cropping and harvest techniques are an area ripe for innovation.
Direct seeding vs. Transplant	Difficulties in striking from imported seed have been experienced in the past, and lack of 'breeding plantations' in New Zealand means that fertile local seed is not available, nor seedlings growing in-situ. Birds that disperse *J.communis* seed in other countries are not present here, and birds here may not be inclined towards *J.communis* in New Zealand, which may impact fertilisation prospects (this may be a positive in that it may limit unwanted plant dispersal). Levels of beneficial conifer mycorrhizae within seeds is also a critical success factor for seed germination, and these may not be present in imported seeds.
Transplanting	Although living juniper plants have previously been imported into New Zealand, due to 1990's regulation changes (Hazardous Substances & New Organisms (HSNO) Act 1996), importation of living plant materials from overseas is now very difficult. Importation of living juniper plant materials is governed by MPI's Nursery Stock Import Health Standard (https://www.mpi.govt.nz/dmsdocument/1152-Nursery-Stock-Import-Health-Standard) and plant materials are subject to at least 6 month's quarantine in NZ's highest level of quarantine facility, for which there is a waitlist of around three years. At the end of the quarantine period only plants which have been found free from regulated organisms will be eligible for biosecurity clearance. (Importation of tissue culture for juniper plants is prohibited.) 'The Great New Zealand Juniper Hunt', undertaken by the partnership of Massey University and Begin Distilling has established that there are very few living specimens of *J. communis* within New Zealand (around 47), even fewer of which are berry producing (fewer than 10). The process of establishing juniper trees from this 'breeding stock' is promising. Massey researchers have identified that there may be sufficient genetic diversity within the New Zealand stockholding. However, it will take time to build this up.
Fertility management	Fertilisers have been observed to have little effect on the growth rate and capabilities of junipers.
Pest & disease management	Juniper can be vulnerable to fungal infections (rusts) and the effects of pests (e.g. Cypress Mealy Bug and Juniper Shield Bug in the Northern Hemisphere). A fungal disease *(Phytophtora austrocedri)* has been severely impacting Juniper trees in parts of Europe.
Weeds	Weeding of small seedlings in nursery settings is needed but weeds are not an issue for established trees.
Crop management	Keeping *J. communis* from becoming too large is important in the context of harvesting. Research suggests pruning to shape to restrict the plant's size, but that you should not remove surplus branches such that a bare patch on the trunk or larger branch is left, as the tree won't produce new shoots from a bare area.
Plant maturation	Trees are slow growing. Massey researchers have observed that seedlings can start to bear cones (berries) at around 3 years, however there are researchers who have observed cones only appearing at around 6 years, or even later. *J. communis* produces cones annually, however berries take three years to ripen (three year old berries ripen late Summer/early Autumn), while un-pollinated cones present in the second year are aborted.

Harvest	Harvesting of juniper berries occurs in late Summer-Autumn by hand picking directly into bags, but alternative methods of harvest involve shaking the plant, causing the berries to fall into containers or laid out canvases. However, the shaking method can result in the collection of immature berries which takes additional time and resources to sort. Harvesting juniper berries is challenging, as *J. communis* trees' branches are very spikey and tree formations can make berry collection difficult also. It may also be labour intensive, and not overly productive in early years, as trees take time to grow and mature, hence returns for juniper will take some time to become commercially worthwhile.
Yields	Berry yield is dependent on the size of the plant (and fertilisation, access to light). Northern hemisphere trees have been observed to produce around 500gm – 1 kg of berries annually per tree, however some trees have been observed to produce around 4-5kg of ripe berries annually.
Post-harvest	Freshly collected berries need to be stored, spread out in a well-ventilated area to avoid overheating as they cure. Overseas, after sun drying, berries are often stored in hessian sacks with good air circulation and minimal temperature fluctuations. Drying of berries via ovens or dryers at low heat until berries achieve a constant moisture content of around 18% is another drying method, and gin makers develop their own methodologies for drying to achieve optimal outcomes for berry volatiles preservation and highlighting. ISO - ISO 7377:1984 also provides some information on packaging and storage, mentioning that juniper berries should be packed in clean, sound and dry containers of a material which does not affect the product and which protects the product from the loss of volatile chemicals. They give examples of such containers, which are tin plate containers, wooden cases and jute bags. In terms of storage and transport, ISO - ISO 7377:1984 recommends that containers of juniper should be stored in covered locations, well protected from the elements and excessive heat. The storage area must be free of odours, with good ventilation and must be protected from insects and vermin. For transport all containers should be transported in such a way that they are protected from unpleasant odours, rain, sun and excessive heat.
Processing	If extracting oils or specific terpenes, the method of obtaining, or extracting the oils can be vitally important to the yield and profile of the oil. The most commonly used methods in context with extraction of berry and other plant-like materials include distillation methods such as steam distillation (SD), distillation-solvent extraction (SDE), microwave-assisted extraction (MAE) supercritical fluid extraction (SFE) and supercritical CO_2 extraction. There are both positives and negatives associated with the use of each method, as no two methods will obtain the exact same volatile composition from the extracted materials. Although distillation achieves the most desirable and comparable compounds for juniper berry extraction, there is always a possibility that the compounds could undergo chemical alteration or heat sensitive compounds being destroyed as they are subject to an intense heating and refluxing period for the extraction of the compounds from the plant materials.

Challenges and opportunities

- The shortage of plants currently available and challenges around developing stocks of genetically diverse, male and female trees (the latter with berry-bearing potential) from existing New Zealand stockholdings of *J. communis*, in lieu of being able to import and grow from either seed or living plant materials easily.
- Understanding the value proposition in terms of odour/flavour profiles of New Zealand-grown juniper will be important to determining product value in terms of gins made from New Zealand-grown juniper, as well as for other products made from juniper or its essential oils.
- The opportunity is certainly there in terms of New Zealand gin makers being keen to source local, however it is going to take some time before New Zealand growers would be in a position to anywhere near meet this demand.

ANGELICA

Angelica Archangelica **(known as Garden angelica, Wild celery, and Norwegian angelica)**

Profile

Thought to be originally from Nordic regions, *A. Archangelica* is a biennial plant from the family *Apiaceae*, a subspecies of which is cultivated for its sweetly scented edible stems and roots.

During its first year, it grows only leaves, but during its second year, its fluted stem can reach a height of 2.5 metres (just over 8 feet), and the root is used in flavouring preparations

Its leaves consist of numerous small leaflets divided into three principal groups, each of which is again subdivided into three lesser groups. The edges of the leaflets are finely toothed or serrated. The flowers, which blossom in January, are small and numerous, yellowish, or greenish, and are grouped into large, globular umbels that bear pale yellow, oblong fruits.

Angelica is short-lived; the herb flowers after two years and then usually dies. However, if the flower stalk is cut before the seeds form, the plant will continue for longer.

The plant is incredibly hardy, in fact *Angelica pachycarpa* is regarded as a pest plant by Environment Southland https://pesthub.es.govt.nz/ , and it also features in the Department of Conservation's list as a pest plant (particularly in Central New Zealand) https://www.doc.govt.nz/globalassets/documents/science-and-technical/drds292.pdf. Once a patch is established, the herb will largely take care of itself.

Benefits and uses

A. archangelica is a versatile plant with many uses. The leaves, stalk, and roots provide economic opportunities; however, the roots are the most common part of the plant harvested for commercial opportunities. Depending on the objectives of growing *A. archangelica* commercially, the leaves can be harvested once or twice throughout the season, however, root crops are only harvested once throughout the plant's life.

Angelica archangelica roots are among the most common botanicals used in gin distillation, often used in concert with juniper berries and coriander as a chief aromatic characteristic for gin.

In addition to being used in gin making, angelica is used for traditional and herbal medicines, for digestion, circulation, and anxiety. Other medicinal uses include anti-cancer applications (for breast cancer) and antimicrobial applications, however there is little scientific evidence to support many of these uses (Healthline, 2020). A standard recommended dose has not yet been established, nor have potential health side effects. Root supplements are sold in capsule and liquid extract form, as well as dried tea.

Infused angelica oil can be used for soothing sore muscles or for its aromatic fragrance. Its roots have a wide range of applications in traditional East Asian and Chinese medicines (e.g. in cough syrups).

Angelica is less commonly used by perfumers and aroma chemists. Studies have found over eighty different aroma compounds from the plant, with Cyclopentadecanolide garnering the most interest. This compound is only present in small quantities (<1% roots, <0.5% seeds) *(Henryk, 2011)*. Other uses include burning the root as incense to help relax the mind and body, and (reportedly) to open the imagination.

Angelica is also used in culinary applications such as jams, and the leaves can be candied to use as a garnish or decoration or can be dried and used in teas or as seasoning. Candied angelica was once a staple ingredient in Christmas cakes. Fresh stalks and leaves can be eaten raw in fruit salads or used as a garnish.

Market profile and Financial Assessment

- We have not been able to find any information regarding the size of the market globally for angelica, however, based on the assumptions outlined in the Snapshot (Existing Spirits Market) we estimate that 50% of New Zealand's median sized distilleries (67 of 134) may currently be using around 1.5 tonnes per annum.
- The 'going rate' that New Zealand gin makers are paying in 2021-2022 for imported angelica root is in the realms of around $300 per kilogram, implying that they may be currently spending around $450,000 on imported angelica root.
- It is currently difficult to project the set-up costs, operational costs and timeframes before significant angelica yields might be achieved from crops grown in New Zealand. It may be some years before this is fully understood.
- If overseas information regarding yield is correct, and around 10 tonnes/ha of fresh roots can be harvested annually, for the washed/dried angelica root alone, assuming a loss of an estimated 80% of weight via drying, this could still result in a potential $600,000 sales value for the crop. However, significant up-front, operational and labour costs may be involved, and a period of 'trial and error' before competitive product were produced and able to gain reputation and traction in the market.
- It is envisaged that New Zealand grown angelica might also serve well to supply Australian and other southern hemisphere gin manufacture. It may also prove worthwhile in the event that traditional Northern Hemisphere sources of angelica become compromised by climate change, disease and/or politics, and also as a distinctive ingredient for overseas manufacturers, especially if New Zealand-grown angelica exhibits world-unique characteristics.
- The market potential for angelica is outlined in **Appendix A**, based on an internet search of commercial products that can be purchased in New Zealand (by The AgriBusiness Group).

Cultivation, Harvesting and Processing

Information available re cropping in NZ	Angelica have been known to grow wild in NZ since 1954 however, to our knowledge, only garden specimens and/or small growing experiments have been conducted to date.
Climate	Originating from cool climates such as the Nordic regions, angelica is resistant to cold temperatures. The ideal growing temperature for *A. archangelica* has been recorded as between 5 °C to 19 °C. The plant should endure severe winter frosts without harm. Angelica grows only in damp soil, preferably near rivers or deposits of water if grown outdoors. When cultivating angelica, soil must be kept moist throughout the germination period to result in high germination and plant establishment rates. Temperature plays a key role in the commercial activities of growing *A. archangelica*. Heat energy is usually used by growers to break the dormancy of the seeds, by using floor heating systems to achieve conditions of between 20 °C to 30 °C. Similarly, stratification of seeds can also be used, which involves cold treatment. Angelica grows best either in full sun or part shade. However, research suggests that during its vegetative growing stage, part shade could improve plant establishment. It is also **important to note** that light contact on angelica roots reduces the essential oil yield, therefore it is recommended that black ground cover is used - especially when it is commercially grown for its roots.
Soil	Different soil types affect the yield, inputs, quality, and post-harvest activities of angelica. To produce high yields of *A. archangelica* roots, soil needs to be ideally free draining, with medium-large pores, to ensure roots can develop. Soil aggregates such as pebbles and stones can affect the yield and quality of roots, as these can cause deformation and stunted growth. Sandy soil has been found to be the most productive soil to grow *A. archangelica* roots in, in an indoor commercial growing system. The smaller pore size of sandy soils allow for higher root yield; however, regular watering and fertilizer input is required to prevent dehydration and nutrient deficiencies. Sandy soil is not recommended in an outdoor growing context due to risk of dehydration - especially in the summer season. Organic soil, particularly soils originating from swamps which are high in humus and organic matter, are the best type of soil to grow *A. archangelica* for roots. The nutrient-rich soil, with medium pore size, allows for ease of root development and for availability of nutrients and water. The angelica plant prefers soil with pH of 4.5 to 7.
Planting	Angelica should be planted in early Autumn at about 50cm apart. It is easy to propagate by seeds, best planted when they are fresh and ripe. If fresh seeds are not available, dried seeds can be used, however the germination rates will be lower (more seeds required). Angelica seeds are sown directly in soil when soil temperatures are above 20°C in late summer. However, seeds can be sown indoors earlier and then transplanted into soil, however care must be taken as transplanting can result in root damage. The *A. archangelica* seeds are not widely available in New Zealand, however, there are retailers such as Puririlane and Egmont Seeds who sell angelica seeds. It is important to not cover the seeds with soil, as they require light to germinate. Established plants should continue to self-seed easily (if some plants are left to go to seed each year), assisted by mulch being pulled back in the autumn to allow the seeds to fall directly onto the soil below.
Direct seeding vs. Transplant	See above and below.
Transplanting	While not recommended, the plant can also be propagated by division in the spring. If transplanting, it is important to do this when the seedlings are still small (less than 10cm), as the sensitive taproot grows long, making it difficult to transplant as it gets larger.
Fertility management	The *A. archangelica* species has a high demand for nitrogen, potassium and phosphorus (NPK) nutrients to achieve maximum yield. However, it is crucial to note that high nitrogen intake will decrease the rate of root development and increase vegetative growth, which will affect the yield of roots *(Kylin, 2010)*. It should be noted that organic methods are likely to enhance product marketability.
Pest & disease management	The plant should be watered from the base to prevent fungal diseases, and mulching will prevent the soil from drying out and inhibit the growth of weeds. Angelica can be vulnerable to root fungal disease caused by *Rhizonia Crocorum*, and also to Powdery Mildew, Downey Mildew, aphids and rodents, which may require growers to supply remedies for (ideally organic control methods in order to enhance product marketability).
Weeds	See above.

Crop management	If the purpose of growing angelica commercially is for its root, pruning is needed during the growing season when flower stalks start to form. It is important to cut off flower stalks as soon as they appear. Pruning of flower stalks is needed to prevent the premature death of the plant.
Plant maturation	See below.
Harvest	The leaves of *A. archangelica* can be harvested throughout the season. Leaves can be harvested manually or using machinery, however care needs to be taken to not damage the main stem. Only young leaves are commonly harvested as the older leaves are much more fibrous and less edible. A sickle is commonly used to harvest leaves in small scale commercial productions. In large-scale production contexts, rotary mowers or forage harvesters have been used to harvest leaves. The harvesting of angelica seeds is done during the Summer months when the seeds turn yellow/ brown and have dried. Harvesting of seeds is usually only done 2-3 years after sowing. The umbels which hold the seeds are harvested manually or using a harvester. Depending on seasonal conditions and health of the plants, seed yield can vary between 1 - 2 tonnes/ha. The roots of *A. archangelica* are available to be harvested in the first year, when the roots have reached around 50 cm in length. Roots from angelica plants grown for seeds are not recommended to be used for commercial purposes due to their inferior quality. The harvesting method is critical to ensure that damage to roots is minimal, therefore avoiding post-harvest quality issues. Angelica roots are usually harvested in the Autumn months (end of March – May), when they are at their best in terms of quality, with higher concentration of essential oils and root yield. Spring (September- November) harvesting of roots can be carried out, however with reduced yield and quality. The foliage and stems of angelica plants are removed before harvesting of roots can be carried out, in order to reduce the occurrence of plant material in the final harvest, which can affect post-harvest activities. Potato harvesters can be used to harvest angelica roots and have been found to be time saving, especially in a large commercial production context. However, manual harvest using garden forks is common in small scale production and is effective, despite being more labour intensive. The roots should be harvested in either Autumn of the first season, or in early Spring of the second, when the plant is directing most its energy into root production and growth (before the stalk has grown tall and is producing flowerheads). Harvesting before roots have a chance to become mouldy and worm-eaten, or too woody and tough is advised. To harvest the root, the whole plant should be dug up.
Yields	The yield of angelica roots can vary depending on seasonal conditions; however, it is estimated that a yield of 10-13 t/ha of fresh roots can be expected.
Post-harvest	Post-harvest activities play a crucial role in preserving of and value adding to angelica leaves, seeds, and roots. Since *A. archangelica* has a short season and does not have a high shelf-life in a fresh form, drying is a key post-harvest consideration in order to extend its economic value. Washing of angelica leaves and roots removes soil, fungi, aggregates, and other plant materials. Angelica roots are cut into large pieces before washing to result in a cleaner finish. Machines can be used in cleaning and washing of roots; however, it needs to be a delicate process to reduce bruising, which can cause quality issues. Drying extends the shelf life of the leaves, seeds, and roots of angelica. There are four components that determine the duration of the drying process; these being air velocity, humidity, temperature, and the amount of material to be dried. The drying process can also be a costly process which can affect economic viability. **Angelica leaves** need to be dried as soon as possible due to the short window of time available before they start to grow mould, leading to rotting. The drying temperature should be between 30–40°C and leaves should be spread in a drying rack with good air flow. Temperatures higher than this range could affect the quality of the dried leaves as essential oils evaporate in hot temperatures. **Angelica seeds** are dried in room temperature with good air flow. The umbels can be hung on a drying line or be placed evenly on a drying tray where seeds can easily fall off from their umbels once dried. The drying process can take around seven days. **Angelica roots** can be used fresh or dried. If being dried, this can be done using commercial dryers or through traditional methods, depending on the amount of roots to be dried. The roots should be cut into smaller pieces or sliced according to the desired shape of the product. Sliced root dries quickly due to the larger surface area exposed, while chunkier pieces will require longer drying periods and be more costly. The roots should be dried with a temperature of 35°C, with good air flow on a drying rack. As with drying leaves, high temperatures will result in the evaporation of essential oil, therefore lowering product quality.

Processing	The extraction of high value essential oil from the root, seeds, and leaves of *A. archangelica* largely avoids the need for drying the plant material. Depending on the scale of production, it may not be economically viable to extract essential oil from angelica from smaller harvests due to the large initial investment needed to purchase oil extraction machinery. Infused oil can be created by adding fresh or dried roots to a carrier oil in a sealed jar – this should be placed in a dark, dry location and shaken daily for 4-6 weeks. This should then be strained and stored in a sealed jar in a cool, dark place for 4-6 months. According to *Kylin (2010)*, the seeds of angelica contains the highest percentage of essential oil content: between 0.6% - 1.5% of total dry weight. This is followed by the roots, which contain between 0.5% - 1% of total dry weight, and finally the leaves contain between 0.2% - 0.3% of total dry weight. Steam distillation is the most common method of essential oil extraction from angelica as it produces the purest form of the essential oil. The process usually takes around 3 to 4.5 hours and requires temperatures of 105°C -107°C. Liquid carbon dioxide extraction is an energy efficient method to essential oil extraction. The essential oil extracted through this process produces higher aroma quality with no by-products and solvent contamination; therefore a higher quality essential oil product. Another method to extract essential oil from angelica is the high vacuum distillation method. The essential oil produced from this method results in high quality volatile aroma chemicals. Angelica essential oil produced from this method is used in producing superior gins as it has a lower amount of monoterpenes, therefore better gin flavour. Packaging of angelica products preserves the quality and locks in the volatile components of the angelica products. The dried angelica roots, leaves, and seeds should be sealed in airtight containers to prevent degradation and contaminants, such as dusts and pests. It is recommended that essential oils are not packaged in PVC or polyethylene products to maintain the quality and integrity of the essential oils.

Challenges and opportunities

- A very quirky challenge relating to angelica harvest is that, if harvested by hand in daylight, pickers are vulnerable to painful instances of phytophotodermatitis due to the chemical compounds in angelica being activated by UV light.
- As with other gin botanicals, New Zealand has limited knowledge about the growing of these, and there will be a large component of 'learning as you go' (as well as R&D requirement) in relation to angelica cropping.
- Understanding the value proposition in terms of odour/flavour profiles of New Zealand-grown angelica will be important to determining product value in terms of gins made from New Zealand-grown angelica, as well as for other products made from New Zealand angelica or its essential oils.
- The opportunity is certainly there in terms of New Zealand gin makers being keen to source local, however it may take some time before New Zealand growers could confidently deliver to this demand, and beyond.

ORRIS

Iris Pallida L. (Florentine Iris)

Profile

Orris root is derived from *Iris Pallida L.*: a rhizomatous perennial with stiff, grey green and sword like leaves.

Also known as the Florentine Iris, it grows to a height of approximately 50 cm and may spread up to 40 cm wide.

The distinctly veined leaves emerge from the rhizomes, growing in a fan shape.

The flowers appear in spring or summer and have the typical iris, flag-like appearance, as the three petals or 'standards' hang or droop downwards. These are joined by three outer petal-like sepals, called 'the falls'. They are generally white, but may have a slight mauve or blue flush to them, with a yellow centre.

Benefits and uses

The economic value of *Iris pallida* derives from both its flowers and rhizomes. The flowers are often used as decorative displays, dyes, and medicinal purposes *(Crisan & Cantor, 2016)*. However, much of the value comes from the rhizomes – also known as orris roots. Medicinal, flavour, and perfumery applications are amongst the common uses of orris roots.

Iris produce stunning flowers during their growing season therefore there are opportunities to harvest flowers during the growing season for the floriculture market. However, there needs to be more research on the impacts of harvesting flowers on root quality if one is growing iris for orris root.

As well as being used in gin distilling, for its flavour and flavour fixing qualities, orris root is also used in many perfumes.

Orris root is primarily used in perfumery as a base note, stabiliser, and fixative to create a wide array of scents, facial powders, talcum powder, dry shampoo, deodorants, and skin care products. It features in many famous fine fragrance brands including Chanel, Prada, and Yves Saint Laurent (The Perfume Society, n.d.).

In India, orris root has been known to treat a variety of heart diseases. In China it has been used to treat inflammations and respiratory problems. The antimicrobial, antioxidant and immunomodulatory properties (to name a few) of orris roots have also made it attractive in applications in modern medicine (e.g. acne treatment).

It is also widely used fixative and stabiliser for the scents in dried flowers (potpourri). Although it is rarely used in cooking, orris root powder features in Moroccan cuisine as one of the many exotic ingredients in the fragrant spice blend 'ras el hanout' (The Epicentre Spices, n.d.). Orris root has natural fluoride properties, so it is used as a base for natural toothpastes.

Market profile and Financial Assessment

- We have not been able to find any information regarding the size of the market globally for orris root, however, based on the assumptions outlined in the Snapshot (Existing Spirits Market) we estimate that 50% of New Zealand's median sized distilleries (67 of 134) may currently be using around 1.5 tonnes per annum.
- The 'going rate' that New Zealand gin makers are paying in 2021-2022 for imported orris root is in the realms of around $280 per kilogram, implying that they may be currently spending around $420,000 on imported orris root.
- It is currently difficult to project the set-up costs, operational costs and timeframes before significant orris root yields might be achieved from crops grown in New Zealand. It may be some time before this is fully understood.
- If growers were to maximise sales of flowers, and roots value-added by processing, the returns could be significant. However, significant up-front, operational and labour costs may be involved, and a period of 'trial and error' before competitive product were produced and able to gain reputation and traction in the market.
- It is envisaged that New Zealand-grown orris root might also serve well to supply Australian and other southern hemisphere gin manufacture. It may also prove worthwhile in the event that traditional northern hemisphere sources of orris root become compromised by climate change, disease and/or politics, and also as a distinctive ingredient for overseas manufacturers, especially if New Zealand-grown orris root were to exhibit world-unique characteristics.
- The market potential for orris root is outlined in Appendix A, based on an internet search of commercial products that can be purchased in New Zealand (by The AgriBusiness Group).

Cultivation, Harvesting and Processing

Information available re cropping in NZ	Information available re cropping in NZ The *Iris pallida* plant is well established and widely available in New Zealand, however it is only very recently (with the recent emergence of a New Zealand gin industry) that growing *Iris pallida* as a crop for orris root production has been considered.
Climate	The *Iris pallida* is a hardy plant with the ability to survive in cold frosty conditions. It is not frost tender and can grow easily in places where most plants could not be grown. As there is no readily available information on the ideal growing temperature of *Iris pallida*. in New Zealand, the region of Tuscany serves as a reference point; Tuscany being known for its high quality orris roots. The region of Tuscany has a mild climate with temperatures ranging between 30°C -3°C throughout the year. It performs well in growing degree days (GDDs) of 1,700 GDDs (Pezzarossa, et al., 2020). *Iris pallida* grows best in full sun and can tolerate shade as well.
Soil	*Iris pallida* is a versatile plant and can be grown in any soils. However, the ideal soils to grow Iris have been identified as light sandy, clay, and loam. The soil type does not drastically affect the growth of the rhizomes as *Iris pallida* is very hardy and can tolerate drought conditions (Mahr, 2021). However, the ideal soil pH for growing is between pH of 6 and 7.5. Soil type does have impact on postharvest activities. As an example, clay soils can stick to rhizomes and roots, therefore more resources are required to wash and clean roots. It is recommended that Iris grown for its roots are grown in sandy soil to produce a higher quality product. Sandy soil helps with keeping the rhizomes dry, especially during harvesting *(Webb James, 2013)*.
Planting	Iris are usually propagated through rhizome division, which is the most effective propagation method. Iris rhizomes are available in New Zealand through garden centres or retailers such as Wairere Nurseries and Meadowland Irises. Iris rhizomes can be planted in late summer with full sun and in a well-draining soil - preferably soils with sand.
Direct seeding vs. Transplant	Seed propagation can be time consuming compared to rhizome division and cuttings.
Transplanting	See Planting above.
Fertility management	There has been no literature found on specific nutrient requirements of commercially grown Iris. However, according to Pezzarossa, et al., (2020), the application of fertiliser does not affect the growth/yield of rhizomes and roots, except for potassium (K).
Pest & disease management	Iris/orris can be vulnerable to Bacterial Soft Rot, Iris Mosaic Virus, aphids, thrip, slugs, snails, hedgehogs and mice, which may require growers to supply remedies for (ideally organic control methods in order to enhance product marketability).
Weeds	*Iris pallida* crops may benefit from the removal of weeds and old foliage in the interests of reducing the prevalence of pests and diseases.
Crop management	The iris plant requires watering during its establishment period, however, once stablished, it is drought tolerant.
Plant maturation	*Iris Pallida* typically blooms in the Spring and Summer months, with flowers ranging from blue to purple. The roots of Iris Pallida can be harvested for orris root three years after planting, in January and February (late Summer) *(Webb James, 2013)*.
Harvest	The flowers can be harvested by manually cutting the lower stem of the flower with secateurs. In a large-scale production, iris flowers can also be harvested by machinery. However, there needs to be more research on the impacts of harvesting flowers on root quality if one is growing iris for orris root. The dry weather in late Summer is ideal for harvesting as the soil breaks easily and the outer skin of the rhizomes are dried, which makes peeling off the skin easier. Rhizomes can be harvested by hand using a garden hoe or machinery, depending on the scale of production.
Yields	Our research to date has not emerged robust information regarding orris root yields.

Post-harvest	Once dug up, the rhizomes should be peeled and stored in a single layer, in a dry, well-ventilated space that does not get any sunlight. The root should be dried for at least two years, as the fragrance does not develop until a year after drying, and continues to increase in fragrance (reportedly peaking at five years). Once dried, the root can be ground to powder. The powder attracts moisture, so it is essential that it is stored in an airtight place and well-protected from humidity. Post-harvest plays a key role in preserving and creating value from Iris flowers and rhizomes. Post harvest activities include washing of rhizomes, drying of flowers and rhizomes, extraction of essential oil, and packaging. Washing of rhizomes involves removing of dirt and this aids in the peeling of the rhizomes' outer skin. A cement mixer is usually used to wash and peel the outer skin at the same time. The washing and peeling play a critical role in preparation for drying. **Flowers** Flowers are generally sold fresh, however iris flowers can be dried by spreading fresh flowers on a drying rack in a cool dry environment. **Roots** Unlike the drying of angelica roots, the drying process of orris roots does not involve the use of artificial heat energy; it therefore requires a longer period. This allows the essential oils in the orris roots to mature. These 'Irones' in dried orris roots are valued for their role in providing the unique aroma and scent of orris roots. Drying and ageing of orris roots allows for irones to develop. Traditionally, orris roots are stored in a dark cool environment for at least three years to develop the formation of irones, therefore increasing the quality of the orris roots. The drying process starts with further peeling of the rhizome's skin and roots, using sharp blades. The rhizome is then peeled; either by using a knife or slicing machine. The sliced orris roots are then left to dry on a drying rack in a cool dry environment with good airflow for 5-6 days *(Crisan & Cantor, 2016)*. The orris roots are then stored for 2-3 years for drying and ageing, which improves their aroma and scent profile. However, the longer the ageing period, the greater the number of irones produced in orris roots, and the greater their value and quality.
Processing	Dried orris root can be sold as it is, however further processing can increase its value and utilisation. The most common further processing of orris roots is extraction of essential oil and milling to form powder. **Powder** Orris roots are milled with the use of a miller to produce orris powder. **Essential Oil** The extraction of essential oil from orris roots involves the milling of orris roots into powders. The powder is then steam distilled to produce orris butter. The orris butter contains irones and myristic acid which are then further purified to produce absolute essential orris oil. **Packaging** Orris roots and powder should be packaged in an air-tight container to prevent contamination and preserve their quality. It is recommended that essential oils are not packaged in PVC or polyethylene products to maintain the quality and integrity of the essential oils.

Challenges and opportunities

- As with other gin botanicals, New Zealand has limited knowledge about the growing of this botanical, and there will be a large component of 'learning as you go' (as well as R&D requirement) in relation to orris root cropping and processing.
- Understanding the value proposition in terms of odour/flavour profiles and Irone composition of New Zealand-grown orris root will be important to determining product value in terms of gins made from New Zealand-grown orris root, as well as for other products made from New Zealand orris root or its essential oils.
- The opportunity is certainly there in terms of New Zealand gin makers being keen to source local, however it may take some time before New Zealand growers could confidently deliver to this demand, and beyond.

LIQUORICE

Glycyrrhiza Glabra L

Profile

The liquorice plant is an herbaceous perennial legume, native to Western Asia, North Africa, and Southern Europe.

Botanically, it is not closely related to anise or fennel, which are sources of similar flavouring compounds.

Liquorice roots are slender and straight, growing horizontally from the plant, and can be considerably branched, sometimes extending over one metre in length.

The long, cylindrical roots are brown, grooved, and rough with a wrinkled, woody appearance. When the outer layers are removed, it exposes a fibrous, yellow flesh, which is what gives the root its famous flavour.

Once established, the plant is hardy, and will tolerate frosts as it dies down for winter. It is considered an easy plant to grow; new plants will grow from any bits of roots left in the soil, making it invasive and difficult to eradicate.

Benefits and uses

The foliage and roots of the *Glycyrrhiza glabra* provide the two main economic values of the plant. As Glycyrrhiza glabra is a legume, the upper part of the plant (foliage) can be used as animal feed, having approx. 10-16% protein content.

However, the liquorice roots are the main objectives of growing *Glycyrrhiza glabra* commercially, as these provide the most economic return.

Liquorice root has a pungent, bitter-sweet taste that is reminiscent of a blend of tarragon, fennel, and anise with notes of camphor.

Liquorice in gin is not really similar to liquorice allsort flavour, being woodier and less obviously sweet. The flavour is not dissimilar to aniseed (another common flavouring for many alcoholic drinks) but the two plants are not related. Liquorice is also prized by distillers for contributing an oily texture to the spirit, increasing its viscosity.

Liquorice is also used as a flavouring agent for foods, beverages, and tobacco products (particularly in some European and West Asian countries). It is available in many forms, including herbal teas, dried roots and herbs, powders, capsules, and liquid extracts.

Dried sticks of liquorice root are a traditional confectionery in the Netherlands (and once in Britain), although its popularity has diminished in recent decades as it has been replaced by more easily consumed confectionery. Dried roots are also used for chewing (for teething children) and as a teeth cleaner.

Surprisingly, most liquorice confectionery is not flavoured with liquorice root, but rather with anise oil (from the anise plant), which has the characteristic smell and taste of black liquorice.

Today, liquorice root is utilised to treat symptoms of indigestion (heartburn and acid reflex), coughs, ulcers, skin conditions, and bacterial and viral infections *(McGrane, 2020)*. Topical gels have also been developed to treat skin conditions such as acne or eczema.

Liquorice has some interesting potential as a Feed Additive – for Poultry, Ruminants and Bees.

The promising prospect of the use of liquorice as a feed additive presents as a potential market opportunity.

Feed Additive (Poultry)

There has been research around the use of liquorice extract as a feed additive for poultry livestock. According to *Alagawany, et al. (2019)*, the addition of liquorice extract in the drinking water of poultry increased feed intake, immune response, and antioxidant parameters. Additionally, the inclusion of liquorice extract in laying hen diets increased immunity. Further studies are required to fully understand and evaluate the benefits and impacts of the inclusion of liquorice extract in poultry diets.

Ruminant Fodder

Liquorice plants are legumes, which indicates that they contain high amounts of protein, and therefore could potentially be used as fodder for ruminants such as cattle, sheep, and goat. In research by Francesca, et al. (2020), it was concluded that the dietary supplementation of liquorice roots to dairy goats increased the nutritional and technological properties of goat milk. The study also found that there was an increase in protein and casein content in goat milk, with reduced somatic cell counts, which indicates that liquorice roots/extracts could potentially be used as a clinical treatment for mastitis.

These findings are further supported by a study conducted by *HuaYing & Xiao (2015)*, which concluded that high concentrations of liquorice root extracts inhibit the growth of *staphylococcus aureus* which is a common gram-negative bacterium that causes mastitis in dairy cows and goats. The findings provide a theoretical basis for the use of liquorice root extracts to treat mastitis organically, without the use of antibiotics. New Zealand's dairy industry continues to reduce its reliance on antibiotics, therefore these findings point to a potentially significant market opportunity for liquorice roots.

Feed Additive (Apiculture)

During Winter and hot Summers, honeybees are usually supplemented by sugar solutions when nectar availability is low. Research conducted by *Al- Shammary & Al-Gerrawy, 2017*, found that feeding liquorice extracts at

20% concentration increased honeybee populations, therefore increasing honey, royal jelly, wax, and propolis production as well.

Furthermore, it also increased the resistance of bees against varroa mites and the ability to get rid of the mite. The varroa mite is a major pest issue in the New Zealand Apiculture industry with an estimated cost of NZD$1.46 million in honey production loss, mitigation and treatment costs every year *(The Country, 2020)*. The opportunity to market liquorice extracts as part of the solution to the varroa mite problem and as a supplementary feed for honeybees is attractive. Further studies into the application of liquorice extract on New Zealand bees and its feasibility is required to further support this market opportunity.

Other less common uses of liquorice include using extracts of the roots as a foaming agent in beers and fire extinguishers, and fibres from the roots can be used for insulation and wallboards, after medical and flavouring constituents have been removed.

Market profile and Financial Assessment

- In 1997, a book (Lange D., 1998) on European medicinal plants signalled that the wild liquorice populations that had been the traditional source of liquorice root had reduced supply, due to unsustainable harvesting. This had led to cultivation of the crop in Europe, to meet market demands.
- According to the Observatory of Economic Complexity (2021), in 2019 the world market for liquorice root extract was US $191 million, with the largest exporters led by France, China, Iran and Germany, each providing 10-14% of the total exports. The top importers were China ($51.1m), Germany ($26m), United Arab Emirates ($12.7m), the United States ($12.5m) and France ($11.8m). However, between 2018 and 2019, the total world export value decreased by 21%, from $240 million to $190 million; the reason for this is unknown.
- Th same source showed that in 2019, New Zealand imported $321,000 of liquorice root and exported $49,000. Unfortunately, this data does not contain information on the quantity exported and imported, which would have been very useful for an estimate on the value of the product.
- The Agribusiness Group have prepared the following economic assessment of liquorice root.

	Activity	$/ha
Direct establishment costs	Pre-emergent herbicides, including application	50
	Cultivation (by contractor)	240
	Drilling (by contractor)	80
	Seed cost @28,000 seeds/ha	35,000
	Base fertiliser	590
Total		**35,960**
Direct ongoing annual costs	Mulching, including sawdust & labour	3,000
	Herbicide spray, including application	90
	Mowing dead foliage in Winter	120
	Mowing foliage in late Spring (prevent flowering)	120
Total		**3,330**
Direct harvest cost	Harvest – plough (contractor)	145
	Harvest – labour	3,500
	Tractor hire	300
	Preparing for drying – cleaning, sorting	2,750
Total		**6,695**
Processing & transport cost	Drying costs	15,000
	Packaging	2,500
	Transport	2,250
	Marketing	
Total		**19,750**
Total direct costs		**55,710**
Revenue (after 5 years of planting)	Harvestable Yield	24,000
	Dried Yield	7,200
	Sale Price	35
Return		**252,000**

ASSUMPTIONS

1. A liquorice crop is established in old pasture areas. The cost of seed bed establishment was based on the cost of fodder beet crop seed bed establishment (from pasture), as per the Lincoln University Financial *Manual (2018)*. To ensure a high-quality seed bed, glyphosate (4L/ha), lorsban (0.2L/ha) and pulse (0.1/ha) were used to ensure a good kill of most weeds and some breakdown of old pasture, totalling $50/ha ($26/ha spray and $24/ha contract sprayer). Cultivation includes ploughing ($145/ha contractor) and multi-purpose cultivation pass ($95/ha contractor). Base fertiliser was applied; 500 kg/ha Nitrophoska Select was top dressed at sowing (Autumn) ($465/ha), and 300 kg/ha 15% Potash Super ($127/ha) was applied in the following Summer. It should be noted that organic methods are likely to enhance product marketability.
2. The seed was sown in late Spring using a conventional seeder ($80/ha). The seeds were sown with 60cm spacing (2.8 seed/m2 or 28,000 seeds/ha). The largest seed bag source found in New Zealand was from King Seeds, which supply a bag of 40 seeds for $4.95. This amounts to $35,000/ha of seed. However, this overestimates the cost of seed significantly, as a larger supplier of seeds (for example 20kg bags of seed) will be far more cost effective due to economies of scale, if available. Further, the cost would be significantly lower if root cuttings could be taken from mature plants, and sprouted in propagation trays, prior to planting.
3. Mulch (20-30cm sawdust) is applied annually in spring, at an assumed cost of $3,000/ha (including labour); this is based on strawberry mulch costs. Weeds are controlled annually, spring applications of post-emergence herbicide ($90/ha including contract spraying price). It should be noted that organic methods are likely to enhance product marketability.

   Dead crop growth is mown in Winter when liquorice is dormant; it was estimated that the cost of mowing this was $120/ha, which is double the DairyNZ[10] estimated cost of mowing pasture per hectare (cutting liquorice root is expected to take longer). Note rabbit control was not accounted for.
4. The plant requires no nitrogen fertiliser (excluding the base fertiliser at sowing), as it fixes nitrogen. No irrigation is required, the field trials conducted showed that liquorice does not require irrigation unless annual rainfall is below 500mm.
5. Once established, it is assumed the crop will be maintained by cutting off new shoots (in the second year) and using these to grow new plants, as well as self-propagating. This means that the seed establishment cost was largely one-off. These shoots must be cut annually in late spring, to prevent the plant from flowering, the mowing cost of $120/ha was used (same as assumed cost of mowing the dead crop growth in winter).
6. Harvest occurred in Autumn of year four. The traditional way to harvest liquorice is by hand, following ploughing to about one metre alongside the rows *(Douglas, et al., 2010)*. The liquorice would then be harvested by hand. We have assumed that the harvest cost would be similar to the cost of harvesting crops such as squash and pumpkin because they have a similar yield.
7. The expected root yield is 24 tonnes, based off the Waikato field trial *(Douglas, et al., 2010)*. Liquorice root contains about 20% of water-soluble extracts *(Karaslan 2014)*. In the calculation of saleable yield, we have assumed that the drying process would remove 70% from the harvestable weight as moisture. A figure of $35/kg was used for the economic assessment in the earlier section: this is half the expected price range for root powder and dried stick as indicated in Appendix A, and incorporated an estimated 50% margin for packaging, transporting, marketing, and selling the final product. This is likely the lowest sales price. Any further processing of liquorice would result in the income increasing accordingly.

Further details on the market potential for liquorice is outlined in Appendix A, based on an internet search of commercial products that can be purchased in New Zealand (by The AgriBusiness Group).

10 https://www.dairynz.co.nz/feed/pasture/pre-graze-mowing/

Cultivation, Harvesting and Processing

Information available re cropping in NZ	Research conducted in the Waikato, Canterbury, and Central Otago found that liquorice roots can grow in a range of New Zealand soils ranging from clay to sandy silt soils *(Douglas, et al., 2004)*. However, light sandy to medium loam soil has been found to be the best soil to grow liquorice roots in, having better yield potential.
Climate	*Glycyrrhiza glabra* have been found to grow well in temperatures between 5°C to 25°C, with growing season starting in early Spring *(Douglas, et al., 2004)*. However, the literature does not go so far as to suggest any optimum growing temperature of liquorice plants to achieve commercial objectives. *Glycyrrhiza glabra* thrives in full sun and can tolerate some shade as well.
Soil	Deep cultivated fertile soil is important for liquorice root production. The ideal soil pH for growing liquorice roots is between pH 5.5-8.2.
Planting	It is estimated that about 250-300 kilograms of wet weight rhizome cuttings are needed to plant 1 hectare of liquorice roots *(Douglas, et al., 2004)*. It can be possible to import fresh liquorice rhizomes from countries which grow liquorice commercially (e.g. India, Iran, China, and Italy). However, importation of biological products requires adhering to the Ministry for Primary Industries' regulation on Importation of Nursery Stock as per the Biosecurity Act 1993: Reference: Glycyrrhiza Page 204 of the Nursery Stock- Import Health Standard. https://www.mpi.govt.nz/dmsdocument/1152-Nursery-Stock-Import-Health-Standard It is recommended that for the first 20 days of the propagation period, the soil is kept moist, in order to speed up the plant establishment process. Potting in containers is likely to be unsuitable, as the plant has long tap roots.
Direct seeding vs. Transplant	Root or seed propagation are used in growing *Glycyrrhiza glabra*. However, root propagation is the most common method of liquorice plant propagation in commercial growing operations. In root propagation, rhizome cuttings from the crowns of the plants are planted directly into narrow furrows in Spring (around 30cm to 1m apart is recommended (Hendry, 2019). If growing from seed, seed is available from the likes of King Seeds and Shaman. Outdoor sown seeds should be planted in cultivated beds in late Spring, once the last frost has passed (the optimal soil temperature for germination is 18-24 degrees (Hardy, 2019)).
Transplanting	The plant will send up new shoots from spreading underground stems, known as rhizomes, from its second year. These can be cut off and used to grow new plants. If moved, the plants are slow to settler, and will not produce much growth in the first two years.
Fertility management	As a legume, the plant fixes nitrogen at its roots, so rarely needs additional fertiliser. Liquorice will appreciate occasional mulching to keep weeds down and retain moisture, while providing extra nutrients. Fertile soil with good applications of manure should be adequate, however a fertiliser application mixture of 100kg N/Ha, 44kg P/Ha and 166kg K/Ha were found by *Douglas et al (2004)* to increase the yield of liquorice roots grown at commercial scale by 34%. It should be noted that organic methods are likely to enhance product marketability.
Pest & disease management	Root rot (Phytium), Powdery Mildew, rust and slugs, snails, rodents and rabbits can be a problem, particularly in the first few years of growth, otherwise it is relatively trouble-free. These pests and diseases may require growers to supply remedies for (ideally organic control methods in order to enhance product marketability). The plant attracts bees.
Weeds	*Glycyrrhiza glabra* has a slow growth rate, with three years before root harvesting can occur. Maintenance includes removal of weeds to ensure there is no plant competition and to minimise risk of pests and diseases.
Crop management	Unless seed is required, the plant is usually prevented from flowering (January to July in New Zealand), so that it will put more energy into producing good quality roots. This is achieved by cutting or pruning back the flowers. In the 1–2-year period of slow growth following planting, inter-row cropping may be undertaken to provide income, but this is not recommended, as cereals and ryegrass have been found to depress liquorice root yields *(Douglas, et al., 2010)*.
Plant maturation	Commercially, liquorice plants are usually not harvested until they are four or five years old, to allow the root system to develop *(Hardy, 2019)*. For example, *Bezzi and Aiello (1996)* found that delaying harvest from 3 to 5 years increased root production from 14 to 23 t/ha (in Italy).

Harvest	Liquorice harvest is similar to asparagus. The root is harvested annually in the Autumn once the plant is dry, by taking the thickest horizontal roots and leaving the deep tap roots and thinner horizontal roots to grow on. It is important to harvest annually, because if left unharvested, liquorice roots can reach huge lengths (8 metres). Harvested liquorice may develop a root system 2-3.5 metres deep, but most of the root mass occurs in the top 300mm, and normally roots are only harvested in the top metre. This is supported by a New Zealand Crop and Food trial *(Douglas et al., 2010)* which analysed the root yields from liquorice root grown in Canterbury and the Waikato and which found that most of the roots are harvested in the top 30cm.
Yields	In Waikato, a yield of 24.4 tDM/ha (tonnes of dry matter per hectare) root yield was achieved over 3.5 years, using 25,000 plants/ha spacing.
Post-harvest	Post-harvest plays a key role in preserving and creating value from the liquorice roots. The post-harvest activities include washing and cleaning of roots, drying, and processing of roots into powder. **Washing** Washing of liquorice roots can be done by machinery or manually. The washing process removes dirt and other plant materials. **Drying Roots** Liquorice roots contain around 50-60% moisture after harvesting. The drying process is crucial as it preserves the quality and shelf life of liquorice roots. Wet liquorice roots can grow moulds which can lead to rotting. The traditional method of drying liquorice roots is through drying in a mix of sun and shade. This method is popular, with low input costs increasing profit margin. Liquorice roots are dried in the sun for 2- 3 days before being dried in shade, with good air flow, for 10-12 days, until the moisture content of the roots is no more than 10%. Heat drying can also be used to dry liquorice roots, however, literature was not found on the effects of heat drying on liquorice root quality.
Processing	**Further processing** Dried liquorice roots are cut to size and graded to be sold in dried form or having been processed further. Extraction of liquorice essential oil, liquorice extract and milling roots into powder are the main further processing activities. **Powder** Dried liquorice roots are processed into powder through milling. **Liquorice Extract** Liquorice extract is obtained through spray drying of liquorice liquid. Firstly, dried liquorice roots are shredded into thinner pieces. Secondly, the shredded roots are boiled in hot water to extract the liquorice. Finally, the liquorice water is then either spray dried or goes through a slow condensation process to produce liquorice extract. **Essential Oil** Liquorice essential oil is produced by infusing oils (olive oil) with dried liquorice roots. **Packaging** Dried liquorice root and powder should be packaged in an air-tight container to prevent contamination and preserve its quality. It is recommended that essential oils are not packaged in PVC or polyethylene products to maintain the quality and integrity of the essential oils.

Challenges and opportunities

- As with other gin botanicals, New Zealand has limited knowledge about the growing of this botanical, and there will be a large component of 'learning as you go' (as well as R&D requirement) in relation to liquorice cropping.
- Understanding the value proposition in terms of odour/flavour profiles of New Zealand-grown liquorice will be important to determining product value in terms of gins made from New Zealand-grown liquorice, as well as for other products made from New Zealand liquorice or its essential oils.
- The opportunity is certainly there in terms of New Zealand gin makers being keen to source local, however it may take some time before New Zealand growers could confidently deliver to this demand, and beyond.

Labour considerations

Gin botanicals ventures are likely to be labour-intensive, especially initially, when there will be a requirement for considerable experimentation. Finding personnel with skills or experience with these novel crops will also be challenging. Those intending to grow or process will need to 'do their own research' but will benefit from liaison with expertise from research institutions and those experienced in ventures which have comparable crops, activities and challenges. The region has a tradition of nursery and growing ventures and currently there are successful enterprises involved in these activities, as well as one of New Zealand's pre-eminent seed importing businesses being domiciled here. The region is starting to see a resurgence within an emerging horticultural sector and growing skills and capabilities in horticulture.

While initially at small scale, this will limit the number of hours of labour needed to some extent, and later, with confidence to scale up, there should be efficiencies able to be achieved due to experience, design of operations for efficiencies and application of mechanisation. It is anticipated that the market value for gin botanicals should compensate for the investments in labour required.

Next steps

YOUR SUPPORT TEAM

Setting up commercial gin botanical cultivation and processing infrastructure will require a range of supporting services and advice. Initial contact should be made with:

- Existing players within the craft alcohol value chain in New Zealand, such as Distilled Spirits Aoteroa and local Taranaki-based gin distilleries
- Horticultural advisors and consultants to assess opportunities and advise on crop establishment and operations (e.g. Farmlands Cooperative)
- Financial advisors to support and/or package development projects.

As the industry is in its infancy in New Zealand, many of these supporting services might initially be provided from outside the region.

FUNDING OPPORTUNITIES

The source or sources of funding for development of a gin botanical cultivation or industry will depend on the circumstances of the party or parties carrying out the development and the structure of the proposed investment.

- Some projects are funded by the landowner – perhaps using equity and cashflow from an existing farming or land use operating in conjunction with medicinal plant development.
- There are also developments part-funded by syndicators where equity is provided from multiple investors.
- Several New Zealand banks have teams with experience in assessing opportunities and providing loans for agriculture developments.
- Other sources of funding may also be available for specific activities such as R&D. Venture Taranaki can advise on whether than are other such funding opportunities available.

CHECKLIST AND ACTION GUIDE FOR INTERESTED INVESTORS

If you are a/an:

- [ ] Existing Taranaki grower looking to expand your offering or connect with other interested parties
- [ ] Taranaki landowner (with a small amount of land) considering how best to make use of your property
- [ ] Investor or entrepreneur considering future trends and growth markets in the food and fibre sector
- [ ] Manufacturer or service provider looking to support the development of an emerging sector.
- [ ] Register your interest with Venture Taranaki.

REVIEW FURTHER INFORMATION

Information for this report was drawn from a wide range of sources, in particular from work completed by Massey students and graduates Talon Sneddon, Shikeale Harris and Alton Gondipon. Where it seemed important to directly attribute other research, the reference is provided.

Get in touch, email branchingout@venture.org.nz

Appendices

APPENDIX A

ANGELICA ROOT

The market potential for the angelica root in New Zealand is outlined in below, based on an internet search of commercial products that can be purchased in New Zealand (by The Agribusiness Group). The source for these products is likely to be imported.

Angelica root products sold in New Zealand.

Product	Details	Cost ($/kg)
Swedish bitters	$30/200ml, sold by a Christchurch supplement company Vita Health[11], product marketed as 'Skybright'.	Unsure of quantity of angelica.
Liquid form	$35/100ml, supplied by a Wellington herbal remedy company.	$350 / litre.
Powder	$13.95 / 100 grams, from Wellington company[12]	
Root used for distilling	Over $100 kg – a Auckland distilling company states that *"Angelica root is by far one of their most expensive botanicals, fetching over $100 per kg[13]"*, however it plays an integral part and helps bind the flavours of our botanicals together. It is expected that 1-3 grams is used per litre of gin.	$100 / kg.
Cut root chips (organic)	$23.45 / 100 grams, sold by a New Zealand company[14], and sourced from Bulgaria.	$235 / kg cut root.
Cut root chips	$22.80 / 250 grams, sold by a botanical business in Rangiora[15]	$91.20 / kg.
Cut root chips	$18.75 / 100 grams, sold by a distillery / gin school business[16]	$188 / kg.

11 https://www.purenature.co.nz/products/orris-root-powder
12 https://www.cottagehillherbs.co.nz/herbal-products-wellington/whole-dried-herbs-and-powders-wellington/
13 https://1919distilling.com/botanicals
14 https://www.alembics.co.nz/product/angelica-root/
15 http://www.kerrindale.co.nz/kerrindale/catalogue/?detail&ItemID=1085&SZIDX=0&CCODE=b+angeorc-250g&QOH=-1&CATID=144&CLN=1
16 https://dstilproject.nz/the-distillers-journal/

ORRIS ROOT

The market potential for orris root in New Zealand is outlined in below, based on an internet search of commercial products that can be purchased in New Zealand (by The Agribusiness Group).

There are a few products sold in New Zealand which seem to be mostly sourced from Morocco, as detailed below. According to The Country (2020), some New Zealand gin distillers' source orris root from the Hawke's Bay, however their scale is not known.

Orris root products sold in New Zealand.

Product	Details	Cost ($/kg)
Powder	$21/100grams, sold by a New Zealand supplement company Pure Nature[17]. Oil can be extracted from this (0.2% of root). Reviews show people purchased it for preserving dried flowers.	$210/kg powder.
Powder	$32/100grams, sold by a New Zealand supplement company Go Native[18], sourced from Morocco.	$320 / kg powder,
Cut root chips	$33.45/100 grams, sold by a New Zealand company and sourced from Morocco[19].	$334.50 / kg cut root.
Cut root chips (organic)	$2.90/10grams, sold by a New Zealand homebrew company[20].	$290 / kg cut root.

LIQUORICE

The market potential for the liquorice root in New Zealand is outlined in below, based on an internet search of commercial products that can be purchased in New Zealand (by The Agribusiness Group).

As expected, the value of the product increases as the raw material is processed, for example dried root was the lowest value at $34/kg, while liquid root extract was the highest value at $250/litre.

Liquorice root products sold in New Zealand.

Product	Details	Cost ($/kg)
Capsules	$35/100 capsules - sold by a New Zealand owned and operated supplement company, Nature's Sunshine[21]. Daily intake of 2 capsules is equivalent to 790mg root.	$1,260 / kg capsules.
Dried stick	$11 for 100 grams, sold by an Auckland Asian-based emporium Wahlee[22].	$111/kg of raw root product.
Dried root	$15.45 for 450 grams, sold by a New Zealand supplement company[23].	$34.33/kg of packaged raw product.
Root powder	$10 for 100 grams, sold by an Auckland based natural product company, Pure Nature[24]. Reviews show people use it for face masks and chocolate liquorice cake.	$100/kg of packaged powder.
Tea	$9 for 20 bags of peppermint (60%) and liquorice root tea (40%), made in UK by Pukka herbs[25].	$225/kg teabags (2 grams each). Note this is 60% peppermint, 40% liquorice root.
Liquid root extract	$15 for 60ml, sold to New Zealand by Piping Rock Health Products (New York based)[26].	$250/litre root extract Note gel products with 1-2% liquorice root extract used for eczema (3 times daily for 2 weeks)[27].

17 https://www.purenature.co.nz/products/orris-root-powder
18 https://www.gonative.co.nz/shop/Ingredients/Herbs+-+Dried/Orris+root+powder+OUT+OF+STOCK+until+2021.html
19 https://www.alembics.co.nz/product/orris-root/
20 https://www.hbmalt.co.nz/index.php?route=product/product&product_id=719
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ABOUT VENTURE TARANAKI

Venture Taranaki is the regional development agency for Taranaki. The organisation is responsible for regional development strategy, enterprise and sector development, investment and people attraction, and major project initiatives which contribute to the inclusive and sustainable growth of the region. Venture Taranaki is a registered charitable trust and a New Plymouth District Council Controlled Organisation, supported by the three District Councils of the Taranaki region.

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