

# Developing a sector by creating community-owned enterprises based on the cultivation and processing of essential oils and medicinal plants in South Africa

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## Executive summary

The production of essential oils and medicinal plant products by communities with access to arable land represents a promising new sector in the agro-processing industry. The Enterprise Creation for Development (ECD) unit of the CSIR transfers technology developed by research institutes, universities and the private sector to communities with the aim of creating new community-based enterprises. The CSIR identifies and evaluates new business opportunities, determines technical and economic feasibility, creates and incubates new business entities and exits once financial sustainability has been proven.

The approach is to collaborate closely with government, industry and community stakeholders to identify and address key technical, marketing and regulatory obstacles that have inhibited the growth of the essential oil and medicinal plant sector to date. A portfolio of projects funded mainly by the Sustainable Livelihoods Programme of the Department of Science and Technology and aimed at establishing new enterprises in rural communities based on cultivation and processing of medicinal and essential oil plants, is implemented. This portfolio of projects includes both firm and sector-level interventions. Sector-level interventions, which include sourcing and packaging of technologies, market studies and management of knowledge related to the sector, are designed to support the enterprise creation activities.

Current projects being implemented include cultivation and distillation of indigenous essential oil crops such as *Agathosma betulina* (buchu) at Genadenberg in Western Cape, *Lippia javanica* at Giyani in Limpopo and rose geranium in Northern Cape, Eastern Cape, Limpopo, KwaZulu-Natal and Mpumalanga. Projects based on indigenous medicinal plants include *Siphonichilus aethiopicus* (African ginger) in KwaZulu-Natal, *Hoodia gordonii* in Northern Cape and *Pelargonium sidoides* in Eastern Cape.

## 1. Introduction

The cultivation and processing of essential oils and medicinal plants have considerable potential to alleviate poverty, especially in the rural areas of the country where options for creating new jobs are limited. Furthermore, the cultivation of indigenous medicinal plants will contribute to the conservation of those species which are in great demand and are therefore excessively harvested from the wild. The CSIR identified a need for developing and transferring technology required by entrepreneurs that wish to establish new enterprises based on production of essential oil and medicinal plant products. This paper provides information on the approach being followed by CSIR in collaboration with university and industry partners towards establishing a national industry based on essential oils and medicinal plants technology and products. Key issues related to markets, technology and regulatory matters that affect the sector are discussed. In addition, chemical analysis and production data are provided for community-based enterprises that cultivate and distill the indigenous essential oil plants, *Agathosma betulina* and rose geranium, respectively.

### • General background on Essential Oils and Medicinal plants

Essential oils are volatile constituents extracted from aromatic crops through a process called steam distillation. Any specific essential oil consists of a number of chemically different secondary metabolites produced by plants. The odoriferous characteristics of the oil determine its application in perfumery, cosmetics, soap, household fragrances, food and beverage flavorings and therapeutic agents. The buyer of essential oils will determine its value mainly on a basis of olfactory properties, which is the result of particular ratios of volatile chemical components. Quality control includes chemical analysis (gas chromatography) used to establish the identity and relative concentrations of the most important ten to twenty chemical

components. These components are typically oxygenated and non-oxygenated hydrocarbons, such as mono- and sesquiterpenes, esters and aldehydes. A specific chemotype of a plant species, when cultivated, harvested and distilled under carefully controlled conditions, will consistently produce the desired quality and quantity of essential oil.

In contrast to expressed plant oils such as sunflower, palm, avocado and grape seed oils, essential oils are aromatic, evaporate easily and occur in small quantities in a plant, typically only 0,1% to 2% of the dry weight of the plant material distilled.

Medicinal plants other than essential oils include processed plant materials such as herbal teas, extracts, cold pressed oils, colorants, flavors, antioxidants, etc. that find application in a host of food, feed, pharmaceutical, nutraceutical, cosmetic and pest control products. Medicinal plants are in demand because of a functional property that can often be linked to a specific secondary metabolite in a plant extract, such as glycyrrhizic acid in liquorice extracts derived from *Glycyrrhiza glabra*. A large number of self-medication products are based on medicinal plants. Typical examples are Indian Ayurvedic treatments and Chinese herbal remedies.

Medicinal plants are sold as minimally processed plant material, extracts, cold-pressed oils as well as in the form of pure compounds derived from highly purified extracts.

## 2. The market for essential oils

- **'Major' and 'minor' essential oils**

For the purpose of determining the market attractiveness of products that can be produced locally, published market information on essential oils requires careful interpretation. The FRIDGE Report<sup>1</sup> indicates a global market for essential oils of more than R6 billion. However, not all these oils can be produced in South Africa due to our specific climatic conditions.

Oils can be classified as 'major' essential oils such as Eucalyptus and citrus oils, or 'minor' oils which

include Rose Geranium, Rosemary, Thyme, Lavender, Chamomile, Jasmine and the indigenous oil, Buchu. Major oils are typically obtained through processing of by-products from the citrus or timber industry, therefore the production of such products is often integrated in large industries not easily accessible to communities. Furthermore, these oils are produced in vast quantities throughout the world and are of low value compared to the minor oils.

At least one local company specializes in value addition to some of these major, low value oils through sophisticated fractional distillation processes and formulation to give value-added flavor and fragrances that fulfill specific client needs. Such beneficiation requires olfactory expertise in the form of technical experts that have been trained to use their sense of smell and taste to evaluate the flavor and fragrance profile of aromatic substances such as essential oils.

The experience gained by CSIR, working with local and overseas buyers of essential oils, is that initiatives aimed at developing the sector should focus initially on producing minor oils, which requires controlled cultivation and processing of specialized crops in specific microclimates. South Africa is blessed with a diversity of microclimates that will allow the country to establish itself as a producer of a basket of the most valuable essential oils. Major buyers prefer oils that can be traced or linked to the cultivation site and processing facility.

- **Global market for essential oils**

It is estimated<sup>2</sup> that the world production of essential oils in 2003 was approximately 130 000 tons, valued at approximately US\$ 1 billion and corresponding to a growth rate of 10% year on year throughout the previous two decades.

The following quote from the FRIDGE Report<sup>1</sup> illustrates the application of essential oils in various consumer markets:

*'Some 50% of the world production of essential oils is used in flavors (predominantly beverages), a*

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<sup>2</sup> Source: United Nations International Trade Yearbook 1999

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<sup>1</sup> NEDLAC Fridge Report, [www.nedlac.org.za](http://www.nedlac.org.za)

further 5% to 10% in phytotherapy and aromatherapy, 20% to 25% in fragrances and 20% to 25% is used for further fractionation for the isolation of aroma chemicals. Within the fragrance category, 70% is used in household products, with another 20% used in toiletries and personal care items and the remaining 10% used in fine fragrances (perfumes).'

- **Competition for essential oil markets**

Essential oils can be produced economically only in certain parts of the world, mainly due to climatic conditions and availability of arable land and low labour costs. In South Africa a number of sought-after essential oil species can be cultivated in the various climatic zones of the country. Countries that can compete with South Africa in markets for well-established essential oils include Egypt, China, India, Brazil, Mexico and the USA.

South Africa's inherent competitive advantage in essential oil production can be summarized as follows:

- **Agronomic potential.** The country has available, arable land and above average sunshine days per year, factors important for creating an essential oil industry.
- **Production in a clean environment.** Products based on essential oils find application in cosmetic and personal care products which are skin-applied, therefore oil crops must not be contaminated by agrochemicals and pollution that are associated with farms near industrial areas or where intensive farming systems based on e.g. aerial crop spraying with pesticides are the norm. South African community farms in rural areas are therefore perceived as excellent areas for sourcing essential oils, compared to the highly populated farming areas of the world.
- **Stable supply.** South Africa does not suffer from climatic disasters such as tropical storms that damage plantations in some of the established essential oil producing countries. Buyers of oils place purchase orders on specific farms in anticipation of supply of material of a particular quality. Should the crop be lost, the oil may be substituted with material

from elsewhere but may have slightly different olfactory properties, which requires expensive reformulation.

- **Quality management on farms.** Many South African farmers have already established an image of excellent quality in various export markets. This general image taken in conjunction with export of high quality essential oils during the pilot phase of CSIR community-based essential oils projects bodes well for future promotion of locally produced essential oils.

Based on close collaboration between CSIR, local farmers as well as local and international buyers of essential oils, the following strategy for positioning South Africa as an essential oil producer of choice has emerged:

- Application of scientific methodology in the matching of crops with prevailing agronomic conditions on farms
- Continuous improvement of cultivation and processing technology
- Significant transfer of skills to farm workers and supervisors and ongoing mentoring for at least three years after launching a new project
- Motivating workers by establishing business structures that ensure maximum ownership on community farms
- Establishing a South African brand of essential oils (cf. success of Australian tea tree oil, Bulgarian rose oil, Reunion geranium oil, etc.)

### 3. The market for medicinal plants

Medicinal plants may be based on well-established, exotic crops such as St. Johns wort, Echinacea and Liquorice, or indigenous plants such as Aloe ferox and Devil's Claw. The markets for these crops are big and well established because the products have been traded for many decades. South Africa has the potential to compete in this market but will have to take market share from current producers. The drivers of success in such a business are quality, price, reliable supply of the product and production in a sustainable and environmentally responsible manner. As a result of ongoing exploitation of plant harvesters in poor

communities in many parts of the world, responsible buyers establish supply agreements with businesses that adhere to 'fair trade' principles, to ensure equitable sharing of benefits with communities involved in the production process.

The markets for new medicinal plants based on South Africa's unique biodiversity appear to be very attractive but there are few examples to learn from, other than herbal teas (Rooibos and honeybush tea, and Hibiscus as a developing opportunity), Marula (expressed oil), *Sutherlandia* (immune stimulation) and *Aloe ferox* (bitters sold as a laxative and the gel for personal care market). However, there is undoubtedly a huge market demand for medicinal plants that fulfill an unmet market need, but with the requirement that such products must be novel and scientifically validated.

- **International markets for medicinal plants in the form of herbal remedies**

According to the World Health Organization (WHO)<sup>3</sup> the world market for herbal medicines is US\$60 billion, growing at a rate of approximately 7%. The following summary by the WHO illustrates the global acceptance by consumers of medicinal plants in the form of herbal medicines:

- In China, traditional herbal preparations account for 30%-50% of the total medicinal consumption.
- In Ghana, Mali, Nigeria and Zambia, the first line of treatment for 60% of children with high fever resulting from malaria is the use of herbal medicines at home.
- In Europe, North America and other industrialized regions, over 50% of the population have used complementary or alternative medicine (CAM) at least once.
- In San Francisco, London and South Africa, 75% of people living with HIV/AIDS use CAM.
- 70% of the population in Canada have used complementary medicine at least once.
- In Germany, 90% of the population have used a natural remedy at some point in their life. Between 1995 and 2000, the number of

doctors who had undergone special training in natural remedy medicine had almost doubled to 10 800.

- In the United States, 158 million of the adult population use complementary medicines and according to the USA Commission for Alternative and Complementary Medicines, US \$17 billion was spent on traditional remedies in 2000.
- In the United Kingdom, annual expenditure on alternative medicine is US\$ 230 million.

The above market information serves to illustrate the attractiveness of natural remedies, especially self-medication products, to consumers in both the developed and developing sections of the global economy. The following comments and calculations are an attempt to estimate, in a worst case scenario, the size of the global medicinal plants market available to South Africa:

- Assume that due to the agronomic potential of the country, availability of technology, intellectual property issues, access to genetic resources, distance from the markets and labour costs the country can in principle produce only 2% by value of the products that constitute the US\$60 billion global trade.
- Assume that existing, foreign businesses purchase medicinal plants as extracts and undertake their own formulation, packaging and distribution, and pay 10% of value of end product to South African producers.
- Assume that South Africa can enjoy no more than a conservative 15% market share of the market for those products it can produce.
- A calculation shows that, based on the above conservative estimates, a market of nearly R120 million can be addressed in the short term by local producers of medicinal plants (extracts, not consumer end products). A realistic target will be R300 million and will require investment in technology and strategic positioning of the country as world-class supplier by establishing a successful track record over the following 5-10 years.
- **South African markets for traditional medicines (informal trade)**

<sup>3</sup> WHO, Fact Sheet no, 134, May 2003  
[www.who.int/mediacentre/factsheets/fs134/en/](http://www.who.int/mediacentre/factsheets/fs134/en/)

Researchers<sup>4</sup> that studied the distribution of traditional medicines sold on street markets in South Africa estimated that approximately 700 plant species are actively traded. These researchers and others<sup>5</sup> estimated that 20 000 tonnes are traded in a year with a value of approximately R 270 million.

The following calculation can be done as a 'reality check' on the above estimations of market size for herbal medicines:

- It is frequently quoted that at least 70% of South Africans (i.e. approximately thirty million people) consult a traditional healer at least once a year.
- It can be safely assumed that in at least 30% of cases the patient purchases traditional medicines prescribed by the healer.
- Based on the assumption that the traditional medicines cost the patient about R30 following the consultation with the healer, a total of R270M spent annually on these remedies appears to be a realistic estimate.
- **South African market size for medicinal plants that may substitute informally traded traditional remedies**

This discussion will focus on the potential of producing and distributing medicinal plants, based on cultivation and processing of indigenous plants, as a substitute for informally traded traditional medicines. The following comments are based on the CSIR's experience working in close collaboration with traditional healers since 1998:

- A popular misconception is that traditional healers (Inyangas or herbalists) do not

believe that cultivated and processed indigenous plants have the same healing power as plants collected in the wild. While it is entirely reasonable that certain healers (in particular Sangomas who focus on the spiritual aspects of their trade) follow this belief, it is CSIR's experience that this standpoint is not widely accepted by healers in South Africa.

- It must be understood that only a certain number of species are suitable candidates to be cultivated and processed with a view to substituting traditional medicines with medicinal plants. The project under discussion aims to describe a strategy for creating a national industry for medicinal plants production and sales, with a view to creating sustainable businesses that provide new jobs, therefore the focus must be on those species that can be economically cultivated and processed.
- A certain portion of traditional medicines consists of the bark of trees and slow-growing bulbs. These species are unlikely candidates for cultivation and processing to produce medicinal plants.
- A purely qualitative and conservative assessment is that at least 15-20% in terms of value of the currently traded traditional medicines can immediately be substituted by medicinal plants should these be available. This estimate implies that in the short term a local market of at least R30 million to R40 million can be addressed by producers and processors of certain indigenous plants.
- Based on CSIR's databases on traditional medicines and public information, it is realistic to expect that at least 50 of the approximately 700 plant species used in traditional medicines can be developed during the following 8-12 years as medicinal plants to be produced through community-based agro-processing businesses. Should such a medicinal plants development programme be successful, the informal and formal markets will tend to merge and a realistic forecast of a local market size for medicinal

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<sup>4</sup> Mander, M., Marketing of Indigenous Medicinal Plants in South Africa, Food and Agricultural Organisation of United Nations, Rome, 1998.

<sup>5</sup> Cunningham, A.B. The Herbal Medicine Trade: Resource Depletion and environmental Management for a Hidden Economy, eds. E. Preston-Whyte and C Rogerson, Chap. 12 pp196-206, Oxford University Press, Cape Town, 1991.

plants, based only on indigenous plants, will be approximately R250 million – R500 million.

### **1.1. Competition for natural product markets**

A number of East European countries and China are already significant producers of medicinal plants. Australia is also investing in the production of medicinal plants, spearheaded by the Rural Industries Research and Development Corporation<sup>6</sup> of the Australian Government. The Essential Oils and Plant Extracts program receives funds from RIRDC, industry, and research institutions. Over \$11 million Australian has been allocated to the program since its inception, including financial and in-kind support.

The strategy for developing the local medicinal plant sector is to focus initially on medicinal plants based on local indigenous plants, thereby limiting competition from foreign countries. It can be expected that success in the market will in due course attract new opportunities including the cultivation and processing of exotic crops traded throughout the world.

- **Medicinal plants**

Compared to essential oils, medicinal plants provide more scope for selling in the form of value-added consumer end products such as capsules, tablets, lotions etc. This is partly due to the fact that a number of companies offer a formulation and packaging service that can assist producers of medicinal plants to add value to their raw material.

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<sup>6</sup> <http://www.rirdc.gov.au/programs/eop.html>

## **4. Technology required to produce essential oils and medicinal plants**

- **Controlled horticulture**

Compared to conventional crops, successful cultivation of essential oil and natural product crops requires additional technology beyond the usual agronomic expertise. Essential oils and medicinal plants are derived from crops that must be cultivated under controlled and carefully selected conditions to ensure optimal production of the sought-after secondary metabolites. While seed companies and the agricultural industry have established uniform genetic lines and standardized cultivation protocols for mainstream agricultural commodities such as maize, wheat, vegetables and ornamental flowers, the same is not true for exotic or indigenous plants. It may be argued that the requirement to optimize secondary metabolite production (as opposed to biomass, seed, fruit, etc.) in essential oil and natural product crops, is comparable to viticulture aimed at wine making. It is therefore expected that small differences in microclimate on farms within a specific region will have a significant effect on the quality of the essential oil and other medicinal plants. This assumption is borne out in the results of CSIR working with local essential oil formulators on specific essential oils produced on different farms in the country. This issue is further complicated by variation in climatic condition on farms from year to year, resulting in a requirement to adjust cultivation, harvesting and processing conditions.

The above scenario implies that in addition to conventional agronomic expertise, the essential oil and medicinal plants farmer that aims to establish crops on new land also requires access to analytical chemical technologies (gas chromatography, high-pressure liquid chromatography, etc.) to determine the chemical composition of harvested material. In the case of essential oils, olfactory evaluation by a flavor and fragrance expert is an absolute requirement. While these requirements appear to be onerous, the scientific, precision crop farmer has an advantage because entry into the essential oil and medicinal plants markets is not straightforward, which limits competition.

- **Essential oils**

Essential oil is extracted from plant material by steam, generated by a boiler, through a distillation vessel filled with the plant material. The heat of the steam breaks the membranes of the essential oil-containing cells in the plant tissue and the essential oil is then released into the stream of steam in the distillation vessel. This intimate mixing of oil and steam facilitates the lowering of the boiling point of the essential oil components and the oil is carried in the vapor phase into a condenser where the oil and steam are cooled to their liquid phases. The condenser empties into an oil separator (Florentine flask), which allows recovery of the oil. The distillation of essential oils requires expensive equipment, stainless steel vessels and correct designs. It is possible to embed the correct processing conditions in the design and operation of the equipment, therefore suitably trained workers can produce oil of consistent quality by rigorously implementing standard operating procedures.

- **Medicinal plants**

Medicinal plant products can be sold in the form of extracts, expressed oils, powders, gels, etc. The processing conditions for such products are readily available and are often similar to what is commonly used in the food industry. Medicinal plants sold as consumer end products may be formulated and packaged as teas, syrups, tinctures, lozenges, tablets, soft gel capsules, sprays, lotions, candles, aerosols, etc.

## **5. Regulatory issues**

The establishment of a national industry based on the production of essential oils and medicinal plants will impact positively on issues such as job creation, skills development in communities, creating export opportunities, protecting indigenous plants used as traditional medicines from over-harvesting through cultivation, making affordable herbal medicines available, etc. However, this initiative will also be subject to the following legal frameworks:

- Access to arable land. In many parts of the country access to arable land (Permission to Occupy) for cultivation is controlled by traditional leaders in conjunction with local

authorities. The process of legal access to such land is sensitive and because title deeds are not available, contractual issues can be complicated.

- Access to irrigation water. Permission to use water for crop production purposes must be obtained from national government and must be supported by the provincial authorities. A business plan must be submitted to demonstrate effective use of the water resource.
- Access to plant biodiversity. The project involves cultivation of indigenous plants, which is subject to the Biodiversity Act and associated regulations. A permit must be obtained for the cultivation of indigenous plant material. In cases where indigenous knowledge was used to develop the natural product, evidence of a benefit sharing agreement with owners of such knowledge must be presented.

## **6. Case study from CSIR's portfolio of projects**

The CSIR undertook a project aimed at creating a community-based buchu essential oil business at Genadenberg in the Western Cape. Genadenberg Natural Products is a Section 21 Company operating a 10 ha *Agathosma betulina* (buchu) farm on top of the Piketberg Mountain. The buchu fields (see Figure 1) are part of a 1000 ha farm owned by the Moravian Church of South Africa and the land is leased from the Church. The Genadenberg oils were distilled with a newly erected distillation facility on site. Oil from this site was chemically analyzed and compared with buchu oil obtained by distilling buchu plants collected from the wild at Goedverwacht, only 20 km away, using a mobile distillation unit.





Figure 1. *Agathosma betulina* cultivated at Genadenberg

The oils from both sites were analyzed using a Thermofinnigan Focus GC gas chromatograph and the percentages of the most abundant/important components in the oils were calculated. The average percentages of components as well as total percentages of pulegone, menthone and diosphenol were calculated.

From Table 1 it is clear that the two locations have different chemotypes of *A. betulina*. The Goedverwacht buchu oil is a menthone chemotype, whilst Genadenberg has a diosphenol chemotype oil. Goedverwacht oils also had a lower average percentage pulegone.

A pulegone content of less than 7% is generally regarded as acceptable to industry. Although Genadenberg oil had a pulegone content of 7.9% in 2008, it is still regarded as acceptable by some buyers. The Genadenberg buchu oil distilled in 2007 had a lower average pulegone content than in 2008. This falls within normal variation levels of 3-4% experienced in the industry. The pulegone content is influenced by the level of active growth in the plants at the time of distillation, which in turn is influenced by timing of and conditions during harvesting.

The Genadenberg distillation factory has a boiler with 900 kg steam generation capability and effective production of about 600 kg steam per hour, which can distill a total of 1 100 kg plant material with a distillation time of 1 hour 15 minutes. It has two separate distillation vessels, each with about 550 kg loading capacity.

The yield of buchu oil obtained at Genadenberg during 2008 (average 1.08 %) was a significant improvement on the yield obtained during the previous season. This improvement can be attributed to the design of the distillation factory erected on site using distillation data obtained with a mobile distillation unit. This allowed for a design that addressed specific efficiency issues such as boiler, vessel, separator and condenser sizes.

Table 1: Comparison of buchu oil from two locations in the Piketberg area

Chemical component (%)	Genadenberg g	Goedverwacht
<i>Alpha</i> -pinene	0,9	1,1
Sabinene	1,6	0,3
<i>Beta</i> -pinene	0,5	0,2
Myrcene	2,3	1,6
Limonene	25,8	15,5
( <i>E</i> )- <i>beta</i> -Ocimene	08,	0,5
Linalool	0,6	0,5
Menthone	7,0	26,3
Isomenthone	21,0	31,7
2-hydroxy-isomenthone	0,3	0,4
Total Menthone	28,3	58,5
<i>Cis/trans</i> -isopulegone	4,2	1,7
Pulegone	3,6	2,8
Total Pulegone	7,9	4,5
<i>psi</i> -diosphenol	12,1	6,4
Diosphenol	14,2	7,3
1-Hydroxy-diosphenol	0,1	0,2
Total Diosphenol	26,4	13,9
<i>trans</i> -8-Mercapto- <i>p</i> -menthan-3-one	0,6	0,4
<i>cis</i> -8-Mercapto- <i>p</i> -menthan-3-one	2,9	1,8

The results obtained from the Genadenberg project demonstrate the importance of securing correct genetic stock when establishing a new plantation. Furthermore, it is clear that an appropriate design



for the distillation factory, preferably based on pilot studies, can ensure good yields of oil which is critical for the financial viability of the essential oil business.

- **Rose geranium essential oil production in a pilot study in KwaZulu-Natal**

Rose geranium is one of the most promising essential oil plant varieties that is currently being cultivated in the country. Pilot studies undertaken throughout the country and a number of commercial-scale rose geranium farms have demonstrated that South Africa has potential to become a significant producer of this oil which is used extensively as a key component of high-value fine fragrances.

The essential oil of rose geranium consists of a number of chemical components that determine the quality of the oil. Pilot studies undertaken by CSIR in KwaZulu-Natal on rose geranium essential oil production gave a preliminary indication that plants cultivated under conditions of water stress give superior quality when compared to plants that are well irrigated (see Table 2). The results of this pilot study, obtained by harvesting and distilling young shoots during February 2007, support the research results recently published by Soundy et al<sup>7</sup>. In addition to excellent quality, oil from the pilot study was obtained in 0.22% yield which is a considerable improvement on the yield of approximately 0,10% to 0,15% expected from a typical rose geranium cultivation site which is well irrigated. However, the pilot study was not designed to give quantitative data based on biomass yield per ha, therefore it is not possible to make conclusions on financial viability of producing oil under conditions of water stress based on this study.

<sup>7</sup> HORTSCIENCE 43(2):500–504. 2008.

Table 2: Rose geranium oil composition of oils produced under conditions of water stress

Compound	Typical geranium oil composition	Geranium oil produced under water stress in KwaZuluNatal pilot study
linalool	1-5	0,79
iso-menthone	2-7	7,46
citronellol	20-30	19,31
geraniol	8-20	21,93
citronellyl formate	8-20	11,92
geranyl formate	3-10	9,56
guaiaiene (6,9)	4-8	6,91
Citronellol:geraniol (ideally 1:1)	1,5-2,0:1	0,88

The oil composition obtained from the pilot study is not typical of geranium oil produced in southern Africa. The citronellol to geraniol ratio of 0,88 is very unusual as is a geraniol % composition that is higher than the citronellol % composition. The iso-menthone % composition of 7.46 % is also unusually high. The guaiaiene and citronellol formate levels are also at levels consistent with high-quality geranium oil. The sensory characteristics of the oil were good. The distillation of very young shoots is known to produce oil high in geraniol<sup>8</sup>. Oil of this type is likely to be well received by international markets if this quality can be consistently produced in large volumes.

<sup>8</sup> Journal of Essential Oil Research, 2006, Volume 18 Special Addition, p 106)