Mauritius Research Council

Value Addition To Essential Oils Extracted From Indigenous Or Chemotype Plants of Mauritius

Final Report

May 2000

Mauritius Research Council

Address:

Level 6, Ebene Heights
34, Cybercity
Ebene

Telephone: (230) 465 1235
Fax: (230) 465 1239
E-mail: mrc@intnet.mu
Website: www.mrc.org.mu

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MAURITIUS RESEARCH COUNCIL

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PHASE I RESEARCH OBJECTIVES

The main objectives to be accomplished in phase I are:

i) the screening and identification of essential oil, from indigenous flora, which shall be unique due to the very nature of the indigenous plants.

ii) the determination and identification of plants in Mauritius that yields essential oils which demonstrate a variety of chemotype. Examples of such plants are Thyme, Geranium, Eucalyptus…

iii) the study of essential oil yields and compositional variations extracted by different extraction method such as water distillation, steam distillation, organic solvent extraction and eventually super critical fluid extraction

iv) to establish their gas chromatograph or Infrared spectrum as "finger prints" of their purity and quality and uniqueness. Testing method for essential oil using GC/IR are fundamental to make possible an effective, reliable qualitative and quantitative assessment of essential oil.

v) to establish the test protocols for these Essential oils that would confirm uniqueness and purity

vi) to seek the application of new vectors of energy for extraction such as Microwave, High Frequency waves other than thermal heat which is the vector of energy in the above classical method of extraction

During PHASE II, we shall then step into the production basics to refine our investigation on the following aspects within a pilot project perspective

i) To seek the opportunity of transfer of technology by testing:
the application of new techniques of extraction such as Supercritical extraction with CO_2
the application of microwave or High frequency for extraction

ii) to measure the efficiency and effectiveness of the different methods of extraction with respect to the type of plants, chemical make-up quality of essential oils obtained, and yield of essential oil

iii) to measure the cost of extraction of essential oil through the different techniques. The measures and data obtained shall provide objective guidance on the implementation of the low cost/simplicity of production process (traditional distillation) for the individual enterprise up to the innovative method of extraction described above, depending on the investment budget.

The Pursuance of the concept refinement will obviously set the solid foundation of the Development of the Essential Oil industry in Mauritius which is the Commercial application of the research programme (Phase III).
These research will definitely lead industrial entrepreneurs to invest on transfer of technology to Mauritius.
As stated, the application of Essential oil is direct i.e. it can be readily used by:
Local blenders of cosmetics to incorporate our local scents
International fragrance industries for incorporation in their collection of perfumes
Food and Beverage industries
Aromatherapy *(briefly it is the external application of essential oils for healing purposes, pleasure and the reduction of stress)* which is now taking considerable importance as everyone is talking of stress.

PHASE I RESEARCH PLAN

The Phase I Research has been developed in five axes namely :

1) Screening of chemotype plants with essential oil potential
2) Screening of indigenous plants existing in Mauritius with essential oil potential

It is very important to assess the flora that would yield essential oil which shows specific characteristics and uniqueness compared to existing commercially sold oils. We shall therefore do a thorough gathering of data from all institutions (e.g. University of La Reunion or of the Indian Ocean region) working with those types of plants and compile for study. Upon screening of the potential plants , we shall then move further in our investigation by analysing the essential oils in the various aspects such as the corresponding plant biology, existing production quantities, growing techniques etc……

3) Extraction of essential oil on selected chemotype or indigenous plant

We shall extract these essential oil by water and solvent extraction in soxlet and measure the yield, seek the best method of extraction and the essential oil conservation conditions. These extracted essential oils shall be the basis of their characterisation through chemical analysis.

4) Establishment of test protocols

We shall adapt the corresponding test such as gas chromatography or infrared and any other available method. We need to set down protocols for the extraction, preparation, chromatographic column, carrier solvent, detection unit (FID…..) for each type of essential oil.

5) Research on innovative method of extraction

We shall study the application of new techniques of extraction e.g. super critical fluid extraction or the use of energy vectors such as microwave or HF waves

The proposed Gantt-chart details the schedule of work to be performed for the research project.

According to the Gantt Chart, the following main axes of research needed to be explored
(I) Screening of Chemotype plants with Essential Oil potential
(II) Screening of Indigenous plants of Mauritius with Essential Oil potential
(III) Essential oil extraction on selected chemotypes or indigenous plants
(IV) Establishment of test protocols for Essential Oil
(V) Research on innovative method of extraction

(I) Screening of Chemotype plants with Essential Oil potential

A literature search on chemotypes plants mainly utilised in the Food and Beverage industry, pharmaceutical industry and Aromatherapy have been compiled into a database List. The following list of plants have Essential Oil potential and those plants marked with an asterisk can be exploited in Mauritius.

- Aniseed – Pimpinella anisum
* • Basil – Ocirrum basilcum

- Bay – Pimenta ralemosa
* • Bergamot – Citrus bergamia
- Black Pepper – Pipper nigrum L
- Bois de Rose (Rosewood) – Aniba rosaeaodora
- Cajeput – Melaleuca minor
- Camphor – Cinnamomum camphora
- Cedarwood – cedrus atlantica
- Chamomile – Athemis nobilis
- Cinnamon – Cinnamomum ceylanicum breyne
* • Citronella – Cyarbopogon winterians
- Clary Sage – Salvia sclarea
- Clove – Eugenia caryophyllata
* • Coriander – Coriandrum sativum
- Cypress – Cupressus sempervirens
* • Eucalyptus – Eucalyptus citriodora
- Fennel – Foeniculum vulgare
- Frankincense – Buswellia carterii
* • Geranium – Pelargonium graveolens
* • Ginger – Aingiber officianale
- Grapefruit – Citrus decumana
- Hyssop – Hyssopus officinalis
- Jasmin – Jasminum gradiflorum
- Juniper – Juniperus communis
- Lavender – Lavendula vera
* • Lemon – Citrus medica
* • Lemongrass – Cymbopogon citratus
* • Lime – Citrus aurantifolia
* • Mandarin – Citrus madurensis
- Marjoram – Marjoana hortensis
- Melissa – Melissa officinalis
- Myrrh – Commiphora abyssinica
- Neroli – Citrus aurantrum
- Niaouli – Melaleuca viridiflora
- Nutmeg – Myristica fragrans
* • Orange – Citrus aurantium dulcis
- Plamarosa – Cymbopogon pelegium
- Patchouli - Pogostemon patchouli peli
* • Peppermint – Mentha piperata
* • Petitgrain – Citrus aurantium amara
- Pimento – Pimenta officinalis
- Pine – Pinus sylvestris
* • Rose – Rosa Centifolia
- Rosemary – Rosmarinus officinalis
- Sage – Salvia officinalis
- Sandalwood – Santalum album
* • Spearmint – Mentha spicata
* • Tangerine – Citrus reticulata
- Tea Tree – Melaleuca alternifolia
* • Thyme – Thymus vulgaris
* • Vetivert – Vetiveria zizanoides stapf

* • Ylang Ylang – Cananga odorata forma genuina

However in order to streamline the research, we have opted to select 3 or 4 plants from above list for study. Our selection has been based on criteria regarding parameters such as:

1) Regional statistics of oils trade (import & export)
2) Comparison of published price lists of suppliers of essential oil
3) Market contacts with Food industries using Essential oil in Mauritius
4) Aromatherapy usage

1) Regional statistics of oils trade (import & export)

Literature search and statistical info have been obtained from the Central Statistical Office (CSO Mauritius) and regional statistical offices regarding Essential oil trades. These data have been compiled in view to assess their commercial interest. The following tables summarise existing data regarding some of the essential oil trades and show the statistics of 'commercial' and known essential oil traded amongst countries in the Region and major country-suppliers in the world (see annex 1: table1, table 2, table 3, table 4)

Table 1: Import of Essential oil by countries in the region
Table 2: Import of Essential oil by countries in the region (breakdown figures) with respect to major supplier-country
Table 3: Export of Essential oil from major country-suppliers to USA and Europe
Table 4: Extract of Central Statistical office (Mauritius) of imports of essential oil in Mauritius - year1998

We can observe that above statistics covers mainly currently and commercially known essential oil such as orange, lime, geranium, lavender, peppermint and vetyver. There is no statistical data for the other essential oils as they are not traded in "comparable" amount to those named above. However we can observe from the tables that figures of "others" essential oil is highly significant in the Mauritian related statistics (Table 1 &2&4). We find it important to query and know about the several essential oils included in the item "others" essential oil.

Contacts have been made with local users and it has been found that the Food and Beverage industries followed by cosmetics and trade of aromatherapy products are the main users of these specific essential oils and these essential oils are of high fob value (table 4)

The following main points can also be observed from the tables

- South Africa in the region is the major consumer of essential oils
- China and USA are major traders of essential oil
- Statistical figures do not indicate Mauritius as a meaningful producer of essential oils

2) Comparison of published price lists of suppliers of essential oil

Price list of the essential oils from major suppliers have been compiled into annex 1 – Table 5
It has to be pointed out here that there is a great variation in prices for the same essential oil for the following reasons:

- purity of essential oil offered varies (organic source...)
- blending of essential oil for aromatherapy uses
- origin of essential oil (here relying on chemotypic particularities for prices demarcation)

3) Markets contacts with local industrial users.

Contact have been made with local users namely in Food and Beverage, pharmaceutical cosmetics small and medium "Food and catering" sectors mostly spices oils re imported for incorporation as ingredients of flavour into products.

It has been noted that "carri poulet" flavours is quite commonly used. There exist no real selling of "carri poulet" on market which is commonly procured in the "back" garden.

We shall in our project explore the innovative idea of extracting oil from "carri poulet "Murraya Koenigii" and eventually see the use of it as essential oil.

4) *Aromatherapy useage.*
All Essential oils in the list given have Aromatherapy useage and direct useage of Essential Oils extracted from plants can be used for specific blending. Purity and chemotypic characters need to be explored for rendering the Essential Oil typical to Mauritius and thus adding commercial value to it.

In the light of the above 4 criteria of research, we have selected Thyme, Coriander and Carri poulet "Murraya Koenigii" for ongoing research.

As such, further literature search on above plants have been done and discussed. We have decided therefore to build up a FACT sheet (Annex 2) – technical data sheet on these plants from existing various literature which need to be verified and completion on ongoing research.

(II) Screening of Indigenous plants of Mauritius with Essential Oil potential

The tree Drypete Caustica which is indigenous to Mauritius has been identified and known to have Essential Oil potential. However the limiting factor to its exploitation is that it is rare and spreading of the tree seems difficult.

One way to "replicate" the tree would be the useage of "in-vitro" techniques. Commercially the essential oil seems not actually "marketable" as it is not known in Aromatherapy for common useage.

(III) Essential oil extraction on selected chemotypes or indigenous plants

The set up for the extraction unit in a pilot industrial size would require an extraction unit of 120 litres capacity for an approximate extraction of at least 20 kg of plant material at a time. Hydro distillation would be used and of essential oil collected would be further separated by a vacuum evaporator

(IV) Establishment of test protocols for Essential Oil

- Research on existing norms regarding the analysis of Essential oil have been done. We have established a list of all existing standard related to Essential oil analysis. (see Annex 3)
  For thyme the standard ISO 4728 : 1992 applies
  For Coriander the standard ISO 3516:1980 applies
  There is no standard or document regarding the testing of carri poulet "Murraya Koenigii"

(V) Research on innovative method of extraction such as Microwave, HF

Literature search have indicated that the use of Microwave is being used in Reunion island.

The limiting factor in Mauritius for the scope of our research is the setting up of a "mini" microwave system for heating up and vapour extraction of Essential oils from plants.

One sophisticated technique which is currently being used is the CO_2 solvent extractor. This method is mainly used for Essential oil extraction for use in the pharmaceutical industries.

We have found that there are engineering companies providing the turnkey solution and commissioning and installation of such technology and equipment investment turning around Rs 2 million. Our selected plants do not need this sophisticated technology for the current market.

Annex 1

Table 1: Import of Essential oil (kg) by countries in the region

	Mad97	Mau 97	Mal 95	SA 96	Tanz 97	Zimb 97
Bergamot	-	6	-	18	29	1
Orange	-	6	-	459	-	1
Lemon	1	-	-	554	-	6
Lime	-	-	-	194	-	3
Other Fruits	-	62	471	321	-	30
Geranium	-	-	-	40	-	4
'Jasmin'	-	-	-	-	5	1
Lavender	-	10	-	57	-	255
Peppermint	-	4	-	1505	55	249
Other Mint	11	-	-	488	3	1
Vetyver	-	-	-	7	-	2
Other E.O	1	187	7	2152	9	252

Table 2: Import of Essential oil (kg) by countries in the region (breakdown figures) with respect to major supplier-country

	Importing countries			
	Madag 97	**Mau 97**	**Tanz 97**	**Zimba 97**
Exporting countries				
Brazil				Orange (1)
China		Peppermint (4)	Other E.O (2)	
France	Lemon (1) Other mints (11) Other E.O (1)	Orange (8) Other fruits (28)		
Germany			Peppermint (35) Other mints (3) Other E.O (7)	Lavander (13) Peppermint (24)
India			Bergamot (2)	
Ireland				Lavander (17)
Kenya			Bergamot (18) Peppermint (20)	
Switz		Other E.O (187)		Jasmin (1)
South Africa				Other fruits (19) Peppermint (12) Other mints (1) Vetyver (2) Other E.O (128)
Thailand				Peppermint (18)
UA Emirat			Bergamot (2)	
UK		Bergamot (6) Other fruits (34)	Bergamot (5) Jasmin (5)	Bergamot (1) Geranium (4)

		Lavander (10)		Lavander (225) Peppermint (95) Other E.O (104)
Zambia				Other E.O (20)
USA			Bergamot (2)	Lemon (6) Lime (3) Other fruits (11)

Table 3: Export of Essential oil (kg) from major country-suppliers to USA and Europe

	Europe	USA
Comoros	Other E.O (4185)	Other E.O (110)
Madagascar	Other fruits (15) Geranium (52) Lavander (72) Other E.O (8216)	Other E.O (583)
South Afr	Orange (119) Lemon (428) Lime (22) Other fruits (283) Other mints (41) Other E.O (2075)	Other E.O (535)
Australia	Peppermint (175) Other E.O (8404)	Lemon (84) Other fruits (31) Lavander (106) Peppermint (479) Other E.O (4354)
USA	Bergamot (170) Orange (7761) Lemon (7213) Lime (4575) Other fruits (3931) Geranium (684) Lavander (385) Peppermint (54093) Other mints (17154) Vetyver (129)	
China	Other fruits (113) Geranium (3527) Lavander (111) Peppermint (6717) Other mints (3331) Vetyver (78) Other E.O (31540)	Lemon (96) Geranium (726) Other mints (1695) Other E.O (13571)
India	Lime (56) Other fruits (68) Jasmin (748) Lavander (34) Peppermint (5229) Vetyver (6796) Vetyver (16) Other E.O (11874)	Jasmin (144) Peppermint (2937) Other mints (4571) Other E.O (5134)
Cote d'ivoire	Bergamot (233) Orange (358)	Bergamot (97) Lime (15)

Table 4: Extract of Central Statistical office (Mauritius) of imports of essential oil in Mauritius – year1998

IMPORTS OF MAURITIUS FOR THE YEAR 1998

IMPORTING FROM	QUANTITY	UNIT	CIF VALUE	(M. Rupees)
Bergamot – ESSENTIAL OILS OF BERGAMOT (INCL. CONCRETES & ABSOLUTES)				
FRANCE	14	KGS	6799	
TOTAL :		14	6799	***
Orange – ESSENTIAL OILS OF ORANGE (INCL. CONCRETES & ABSOLUTES)				
FRANCE	570	KGS	49213	
TOTAL :		570	49213	***
Lime – ESSENTIAL OILS OF LIME (INCL. CONCRETES & ABSOLUTES)				
GERMANY, FEDE	100	KGS	111672	
TOTAL :		100	111672	***
Other Fruits – ESSENTIAL OILS OF CITRUS FRUIT EXCL BERGAMOT, ORANGE, LEMON OR LIME				
FRANCE	4947	KGS	1155200	
UNITED KINGDOM	850	KGS	475312	
SOUTH AFRICA	170	KGS	243371	
GERMANY, FEDE	123	KGS	43540	
INDIA	67	KGS	27917	
TOTAL :		6157	1945340	***
Geranium – ESSENTIAL OILS OF GERANIUM (INCL. CONCRETES & ABSOLUTES)				
REUNION	100	KGS	307493	
UNITED KINGDOM	2	KGS	2119	
TOTAL :		102	309612	***
Lavender – ESSENTIAL OILS OF LAVENDER OR LAVANDIN (INCL. CONCRETES & ABSOLUTES)				
UNITED KINGDOM	259	KGS	213689	
TOTAL :		259	213689	***
Peppermint – ESSENTIAL OILS OF PEPPERMINT (MENTA PIPERITA) (INCL. CONCRETES & ABSOLUTES)				
UNITED KINGDOM	204	KGS	148627	
CHINA	50	KGS	26772	
TOTAL :		254	175399	***
Other Mint – ESSENTIAL OILS OF OTHER MINTS EXCL. PEPPERMINT				
INDIA	158	KGS	18502	
TOTAL :		158	18502	***

Other E.O – ESSENTIAL OILS NOT THOSE OF CITRUS FRUITS, EXCL Geranium-Vetyver				
SWITZERLAND	6028	KGS	3485791	
GERMANY, FEDE	7299	KGS	598910	
FRANCE	1061	KGS	349269	
UNITED KINGDOM	947	KGS	334836	
SOUTH AFRICA	765	KGS	122500	
INDIA	205	KGS	60880	
MALAYSIA	145	KGS	10082	
TOTAL :		**16450**	**4962268**	***
33019011 – AQEOUS DISTILLATE & SOLUTION OF ESSENTIAL OIL SUITABLE FOR MEDICINAL USE				
FRANCE	5172	KGS	1458762	
UNITED KINGDOM	1171	KGS	189333	
INDIA	360	KGS	84083	
AUSTRALIA	40	KGS	19851	
TOTAL :		6743	1752029	***
33019019 – ESSENTIAL OIL CONCENTRATE IN FATS, OIL ETC; TERPENIC BYPRODUCTS				
FRANCE	35	KGS	24121	
TOTAL :		35	24121	
33019090 – AQUEOUS DISCILLATE & SOLN OF ESSENTIAL OIL NOT FOR MEDICINAL USE				
FRANCE	796	KGS	274430	
UNITED KINGDOM	980	KGS	189450	
UNITED STATES	25	KGS	38234	
SWITZERLAND	50	KGS	34985	
MALAYSIA	85	KGS	15157	
INDIA	162	KGS	13612	
JAPAN	12	KGS	7950	
SOUTH AFRICA	1	KGS	1017	
TOTAL		2111	574835	***

Table 5: Comparison of published pricelist (USD) of suppliers of essential oil

10 ml =1/3 oz	PLANTAIN	EARTH/HARMONY	ELIZABETH VAN BUR	SENSIA	ESSENTIALLY OILS	MALLONS	LEGEND	AVERAGE
□ Basil – Ocirrum basilcum	3.04	14.75	14.94	6.00	3.92	7.36	6.80	**7.75**
□ Bergamot – Citrus bergamia	1.99	14.50	0.00	8.75	3.43	3.40	4.00	**6.24**
□ Black Pepper – Pipper nigrum L	4.50	14.50	20.19	14.75	4.45	0.00	0.00	**6.49**
□ Camphor – Cinnamomum camphora	0.72	0.00	0.00	0.00	1.25	0.00	0.00	**1.11**
□ Chamomile – Athemis nobilis	12.65	15.00	0.00	0.00	11.07	10.00	20.00	**10.49**
□ Cinnamon – Cinnamomum ceylanicum breyne	0.96	8.00	10.94	0.00	1.50	1.90	2.50	**4.26**
□ Citronella – Cyarbopogon winterians	1.08	7.00	0.00	8.00	1.35	0.00	2.50	**3.10**
□ Clove – Eugenia caryophyllata	0.60	11.75	9.38	5.75	1.55	0.00	2.50	**4.82**
□ Coriander – Coriandrum sativum	1.50	0.00	9.56	10.00	2.50	0.00	3.50	**3.01**
□ Eucalyptus – Eucalyptus citriodora	0.87	9.06	10.50	6.25	1.66	1.50	2.58	**4.86**
□ Geranium – Pelargonium graveolens	2.63	14.75	15.94	9.00	3.82	2.80	4.48	**5.94**
□ Ginger – Aingiber officianale	2.30	11.00	12.31	14.50	2.60	0.00	3.95	**6.32**
□ Grapefruit – Citrus decumana	1.56	11.25	0.00	5.00	1.60	0.00	2.50	**2.43**
□ Jasmin – Jasminum gradiflorum	0.00	19.75	0.00	0.00	0.00	0.00	47.50	**7.47**
□ Lavender – Lavendula vera	1.94	11.50	13.13	9.75	2.90	2.60	3.82	**7.01**
□ Lemon – Citrus medica	1.02	8.75	7.44	5.50	1.65	1.50	2.50	**4.44**
□ Lemongrass – Cymbopogon citratus	1.08	7.75	0.00	4.83	1.63	1.50	2.65	**3.52**
□ Lime – Citrus aurantifolia	1.08	10.50	7.44	5.75	1.45	1.90	2.95	**3.45**
□ Mandarin – Citrus madurensis	1.84	12.00	17.38	8.75	2.68	2.50	2.95	**5.34**
□ Orange – Citrus aurantium dulcis	0.87	8.00	6.81	4.75	1.85	1.30	2.10	**4.04**
□ Peppermint – Mentha piperata	1.20	10.38	0.00	5.00	2.48	1.90	2.95	**4.24**
□ Pine – Pinus sylvestris	1.68	8.50	0.00	9.08	2.05	1.90	2.95	**2.91**
□ Rose – Rosa Centifolia	30.00	19.00	0.00	0.00	60.00		55.00	**24.33**
□ Rosemary – Rosmarinus officinalis	0.00	11.00	8.94	5.50	0.00	1.90	0.00	**4.94**
□ Spearmint – Mentha spicata	2.10	11.50	9.38	6.00	1.45	0.00	0.00	**3.38**
□ Tangerine – Citrus reticulata	2.41	10.00	0.00	5.75	1.75	2.80	0.00	**2.52**
□ Thyme – Thymus vulgaris	1.50	28.00	16.13	14.00	3.93	0.00	7.95	**10.22**
□ Vetivert – Vetiveria zizanoides stapf	2.30	21.00	13.69	11.75	3.55	2.80	4.30	**8.25**
□ Ylang Ylang – Cananga odorata forma genuina	2.46	15.00	20.63	13.50	2.86	3.90	4.75	**10.00**
MEAN	**2.96**	**11.87**	**7.75**	**6.82**	**4.51**	**1.91**	**6.82**	

FACT SHEET

Annex 2

Coriander – *Coriandrum sativum*

Coriander is an annual herb that belongs to the carrot family – Umbelliferae. It is extensively grown in India the Soviet States, central Europe Asia, Morocco, and South and Western Australia.

The coriander plant yields two primary products that are used for flavouring purposes: the fresh green herb and the spice. The latter is the dried form of the whole mature seed capsule (fruit) but is frequently termed 'coriander seed' in commerce. The odour and flavour of these two products are markedly different. The herb is used for culinary flavouring purposes in Asia, the Middle East, and Central and South America. The fruits are an important ingredient of curry powder. They are used as a pickling spice, in seasonings and sausages and also in pastries, buns, cakes and other confectionary. Coriander oil is used to flavour alcoholic beverages, candies, meat, sauces and tobacco. The fruits and oil are used to cover the taste or correct the nauseating or griping qualities of other medicines. They are used medicinally for a number of purposes, particularly to relieve flatulence.

In commerce, coriander is broadly divided into two types according to the size of the fruit. Fruit size is an indication of volatile oil content and suitability for particular end uses. Variety *vulgare* or *macrocarpum* has a fruit diameter of 3-5 mm while var. *microcarpum* fruits have a diameter of 1.5-3 mm. Large fruited types are grown mainly by tropical and subtropical countries, e.g. Morocco, India and Australia and contain a low volatile oil content (0.1-4%). They are used extensively for grinding and blending purposes in the spice trade. Types with smaller fruit are produced in temperate regions and usually have a volatile oil content of around 0.4-1.8% and are therefore highly valued as a raw material for the preparation of essential oil.

Coriander is an annual. It is erect and has a tap root. The flowering stem, which is slender and smooth, reaches a height of 20-120 cm. The flower, in compound umbels, bears small white or pink flowers that bloom in January to February. Hermaphrodite and staminate flowers may occur in each umbel. The fruits are nearly globular, 3-4 mm in diameter, and are yellow-brown when ripe. The fruits consist of two halves – single-seeded mericarps. The unripe fruits smell of bedbugs, but become pleasantly aromatic on ripening.

Crop production

Coriander is always propagated from seed. Often, before sowing, fruits are rubbed until the two mericarps are separated. A clean and reasonably fine seedbed is required. The plant is not sensitive to cold and is quite resistant to heat and drought. Crop management and requirements are similar to other broad acre crops e.g. rape seed oil crop. Yields are best on free draining soils where there is adequate moisture during the vegetative phase of the crop. The seedling is relatively slow to develop and weed control is important during establishment. Reproductive stem growth is very rapid and competitive against weeds. Heavy rain during the period of stem extension can be hazardous, resulting in lodging and breaking off of the soft fleshy reproductive stem. Seed is sown at a seeding rate of 5-30 kg/ha. Lighter seeding rates produce large, more robust plants but the period of flowering and fruit development is spread over a longer period. High seeding rates results in fewer umbel classes being produced but a far greater risk of crop lodging. Seed is drilled with a grain drill at 20-30 mm depth and drill rows are 15-30 cm apart.

The microcarpum seed type required between 100 and 140 days growing season and ranged in height from 80 to 150 cm. Whereas the vulgare seed type matured earlier, 75-90 days, and ranged in height from 20 to 50 cm. Essential oil production is probably only viable based on the microcarpum seed types.

Flowering and fruit maturity of coriander is indeterminate making it difficult to identify the most appropriate time to harvest and the method of harvest. Delaying harvest to allow umbels that are slow to form to reach maturity can result in fruits on the primary umbel shattering. Seed shatter and loss of a complete class of

umbel can occur within a period of a few days under windy conditions. Results of previous trials indicate that the primary umbel can make up 10-30%, and the secondary umbel 50% of the total yield (at sowing rates of 30 fruits/m of drill). If the crop is desiccated or windrowed both methods can result in a significant loss of yield if the weather conditions are unfavourable for any length of time after desiccation or windrowing has been carried out.

Spice quality

The size, volatile oil content and aroma/flavour character of dried, mature fruit are principally governed by the intrinsic properties of the cultivar grown. The stage of maturity of the fruit at harvest is also of paramount importance in determining the quality of the spice. Immature fruits contain a higher volatile oil content than ripe fruits, but the aroma of the immature fruits is generally considered to be disagreeable by consumers in Western countries. The characteristic, sweet and spicy aroma of the spice does not develop until the fruit has attained maturity and commences to dehydrate on the plant. So it is important to harvest the fruit at the right stage. Since fruit ripening on the plant is not simultaneous but progressive, judgement is required to decide on the optimum time for harvesting – normally when a fair proportion of the fruits on an umbel have changed colour from green to grey-green or yellow.

Over-ripening of the fruits on the plant should be avoid or yield is reduced. If the fruits are allowed to become too ripe there is a distinct risk of shattering during harvesting and post harvest handling. Splitting of fruits is undesirable for two reasons: firstly, it spoils the appearance of the whole spice, and secondly, it can lead to considerable loss of the volatile oil during subsequent storage.

At harvest, the moisture content of the fruits may be greater than 20% and it must be reduced to 9% or less during drying. If the fruits are not thoroughly dried they absorb heat very readily resulting in deterioration of both the colour and flavour of the spice.

Cleanliness of the product is important in the marketing of this spice. Fruits should be thoroughly cleaned to remove extraneous matter such as stalks, plant debris and soil.

Essential oil

Coriander oil is prepared by steam distillation of mature, dried fruits. Distillation of the oil is hindered by the fact that the oil cells are located within the mericarp of the spice, which are protected by a thick cell wall, and also by the high fat content, which tends to occlude the volatile oil and reduce the vapour pressure. To obtain the maximum yield of essential oil and to reduce the processing time, it is necessary to crush the spice prior to distillation. Overheating of the spice during the crushing operation and undue delay when loading the crushed material into the still must be avoided since volatile oil loss by evaporation can readily occur.

Variations have been noted in the literature between the odour characters of oils from different types and sources of the spice. Moroccan and Indian coriander oils are generally regarded as inferior in odour quality to European spice oils.

The composition of the volatile oil, which determines the odour and flavour character, has been of particular fascination to chemists. In the unripe fruit and herb, aliphatic aldehydes predominate in the steam volatile oil and are responsible for the peculiar, fetid-like aroma (an important flavour component of Thai cuisine). On ripening, the fruits acquire a more pleasant and sweet odour and the major constituent of the volatile oil is the monoterpene alcohol, linalool. In the unripe fruit, two types of volatile oil canals are present. One type is located on the periphery of the fruit and these canals are present. One type is located on the periphery of the fruit and these canals contain a volatile oil comprised predominantly of aldehydes. The second type of canals is buried in the mericarp of the fruit kernel and the composition of their volatile oil is very different. The major component is linalool together with some other oxygenated monoterpenes and monoterpene

hydrocarbons. As the fruit ripens on the plant, the peripheral canals flatten, begin to lose their volatile oil, and the odour of the fruit changes. On drying to around 7% moisture content, the outer canals completely lose their volatile oil but the inner canals remain intact and the characteristic odour and composition of the volatile oil of the spice are attained.

The essential oil obtained through steam distillation of the fruit is a colourless or pale-yellow liquid. The aroma has been described as pleasant, sweet and somewhat woody and spicy, with a floral-balsamic undertone and peppery-woody topnote as the characteristic features. The flavour is described as mild, sweet and spicy-aromatic yet somewhat warm and slightly burning. In depth analyses of the oil have identified 203 individual components in coriander fruit oil. The 18 main components constitute 97% of the total oil without giving the odour impression of coriander oil when reconstituted in the concentrations found in the natural sample. Therefore a major sensory effect of the oil comes from the 180 trace components that occur, on average, in concentrations of about 0.01% or less. The inclusion of unripe fruits or other over-ground parts of the plant during distillation of the fruit imparts an obnoxious odour to the oil. The oganoleptic properties of the distilled oil tend to deteriorate during prolonged storage especially if left exposed to light and air. An International standard detailing quality requirement for coriander is the ISO 3516:1980

Production, trade and markets

In addition to the spice, considerable quantities of the fresh, green herb are consumed domestically in Asia, the Middle East, and Central and South America. Interest is increasing amongst commercial food processors in using the herb oil to flavour ethnic food.

India is probably the largest producer of fresh, green coriander although most of it is produced for the domestic market. Production in Europe and Eastern Europe is substantial. In Soviet States coriander is grown mainly for the production of the essential oil. Probably the largest consumer in the Economic Community is Germany.

FACT SHEET

Thyme – *Thymus vulgaris*

Synonyms: wild thyme, common thyme, garden thyme.

Thyme, a small, upright shrub growing 20-40 cm in height, belongs to the *Labiatae* family. Pink to lilac, and rarely white, flowers are borne in clusters near tips of shoots in early summer. Leaves are small and grey-green.

Other species of regional importance for both culinary herb and essential oil production include *T. serpyllum, T. zygis and T. mastichina.* Lemon-scented cultivars of thyme are grown on a small scale for fresh and dried culinary herb production.

Thymus vulgaris is native to the western Mediterranean region, extending to south eastern Italy. *Thymus serpyllum* has a wider natural range in much of western Europe, while *T zygis* and *T. mastichina* are restricted to the Iberian Peninsula.

Uses

Fresh and dried thyme is used as traditional culinary seasoning. The essential oil is also extracted from the herb and used in both perfumery and flavouring applications. The essential oil has useful antioxidant activity. Thyme is also regarded as a medicinal herb with antispasmodic, expectorant and flatulence reducing action. Thymol, a major constituent of the oil, has antibacterial, antifungal and anthelmintic activity.

The dried herb is used to give flavour to meat and meat products, condiments, relishes, soups and gravies. Thyme is an ingredient in mixed herbs. Lemon thyme is often used to flavour fish dishes.

The essential oil of thyme is mainly used in flavouring applications in the processed food industry. It is also used to fragrance soaps and detergents where its characteristic fresh, antiseptic aroma is desired.

Thyme produces a distinctive honey that is beginning to find niche markets in Europe and Asia.

Thyme was grown without irrigation in very dry conditions, its productivity is low and increases substantially if irrigation is applied to the crop.

Soils must be very free draining and pH should be around at least 6.0 for crop abundance.

Agronomy

The crop can be established from seed or by cuttings. Some variability in plant growth habit, flowering time and productivity occurs in a crop established from seed. Thyme seed is very small but can be sown directly in the field at a rate of 5 kg/h. Variable crop establishment is a risk in a direct-seeded crop. Alternatively, seedlings can be established in a nursery bed or cell trays, and transplanted into the field.

Thyme grows easily from 5-10 cm cuttings taken in spring. Root-promoting hormone may be beneficial. Plants with superior characteristics can be selected and propagated from cuttings to reduce variability in the crop.

Transplants (cuttings or seedlings) can be established in beds approximately 1.5 m wide. Ideally, beds should be designed so that machinery straddles the crop and plants are not squashed, which thyme will not tolerate. A spacing of 25-30 cm between plants in beds is recommended.

Harvest management of a thyme crop is critical. If the crop is left too long between harvests or is cut too hard, plant death can occur, particularly in wetter environments. Disease infection may contribute to plant deaths in crops weakened by heavy cutting. Harvesting should, therefore, be frequent and cutting height adjusted to leave some green herbage on the plants after cutting.

Thyme suffers from few pests and diseases. However, in wetter environments with imperfect soil drainage, root-rotting fungal diseases have been implicated in plant death.

Essential oil yields peak in hot summer conditions. Yields of 1.0% (10 ml oil/kg fresh thyme) can be expected from wild thyme. Yields from cultivated material range from 0.05 to 0.50% depending on variety. However, herbage yields under cultivation far exceed production in the wild, so more oil would be produced per hectare in cultivated crops.

Soil tests should be carried out to determine fertiliser requirements. A basal fertiliser application containing nitrogen, phosphorus, potassium and sulphur should be applied annually. Thyme responds well to additional applications of nitrogen during the growing season, usually applied after each harvest to promote new shoot growth.

Processing and quality

Traditionally, large amounts of thyme were sun-dried, but final product quality was poor. Artificial drying methods allow better control of product quality. A forced air-flow drier would be suitable. Thyme should be dried at temperatures lower than 40°C to reduce loss of flavour through volatilisation of essential oil, and to maintain a good green colour.

The dried product must then be processed to remove leaf material from stems, and sieved to remove dust and produce a uniform product.

An International Standard detailing quality requirements for dried thyme is ISO 4728:1992. An important factor contributing to the flavour intensity and, therefore, quality of thyme is the essential oil content of the dried herb. Whole thyme leaves must contain 0.5% essential oil (5 ml/kg dried herb), and ground thyme must contain 0.2% essential oil to meet International Standard requirements.

Essential oil of thyme can be extracted by steam distillation of the fresh herb. The essential oil is located in small glands on the leaves. Yield and quality of essential oil varies according to the genetic make-up of plant material, crop maturity at harvest, environment and distillation practice.

Chemical composition of thyme oil is very variable with seven distinct races (chemotypes) identified in Europe. There are at least 6 chemical variations within the species, two of which contain principally a phenol, either thymol of carvacol, while the others have an alcohol as the main component. The alcohol may be linalol, geraniol, thujanol-4 or –terpineol. The chemotypes are written as Thymus vulgaris ct. carvacol, Thymus vulgaris ct. thymol, Thymus vulgaris ct. linalol, Thymus vulgaris ct. geraniol, Thymus vulgaris ct. thujanol-4, Thymus vulgaris ct. –terpineol

Often the common names of these will be reflected by their chemotypes: those with phenolic components are called red thymes, while those with alcohols are called sweet thyme. In cases where thyme is collected from the wild without regard to chemotype, it is known as population thyme. It is only by propagating plants from each chemotype i.e. cloning, that a chemotype will remain distinct. If seeds re used from a particular chemotype, there is no guarantee that the resulting chemotype will be the same as that of the parent. These plants are also known as population thyme

Markets

Most bulk dried herbs are produced in countries with low labour costs, so the challenge for Mauritius is to produce crops of superior quality at a competitive price.

Europe is a major consumer of thyme together with US. Trade statistics indicate the US imports around 1000 t of dried thyme annually.

FACT SHEET Curry leaves – *Murraya Koenigii*

It is a small deciduous tree that has hard, useful wood. The tree belongs to the Rutaceae family (citrus family) and is of Southern India and Sri Lanka origin. Leaves are pinnate, with 15-20 leaflets. The leaves contain essential oils when braised, gives a distinctive smell like that of a faint odour of anise. Curry leaves are used in the Asian cuisine and is known in different names: the table below shows the different common names of the curry leaves:

Bengali	Barsunga
Burmese	Pindosin, Pyim daw thein
Dutch	Kerriebladeren
English	Curry leaves, Nim leaves
French	Feuilles de Cari, Feuilles de Curry
German	Curryblatter
Hindi	Meetha neem, Kari patta, Katneem, Bursunga
Icelandic	Karrilauf
Indenosian	Daun kari
Italian	Fogli di Cari
Kannada	Karibevu
Malay	Daun kari pla, Karuillam
Malayalam	Kareapela
Marathi	Karipat
Mauritian creole	Feuilles Carri poulet
Oriya	Basango
Punjabi	Bowala
Sanskrit	Girinimba, Suravi
Singhalese	Karapincha
Spanish	Hoja
Swahili	Bizari, Mchuzi
Tamil	Karuvepila
Telegu	Kerepeku, Karivepaku
Thai	Bai karee

Uses

Fresh and dried leaves are used as culinary seasoning. All Asian cuisine uses the leaves for incorporation in the food or preparation of spices blends for the preparation of dishes. Uses of the essential oil can be used instead of the dried leaves as they lose their delicate fragrance easily within days. Curry powder contain curry leaves and derive its taste from a blend of spices mainly form roasted cumin, roasted coriander, black pepper, chiles and roasted fenugreek and tumeric (yellow colour). Additionally, ginger, lentil flour, salt and sweet spices (cinnamon, cloves and green cardamon)

Agronomy

The tree is usually grown wild in the backyard and transplants (cuttings) can be effected for propagation. The tree produces fruits (slightly larger that a pea) that ripen into pupleish/black containing the grains. Study in its agronomic

Processing and Quality

From the literature, fresh leaves may contain up to 2.6% essential oil. Extraction done gave a very low yield, approx. 0.1% from fresh leaves. The following aroma components are beta –caryophylene, beta-gurjunene,

beta-elemene, beta-phellandrene, beta-thujene, alpha-selinene, beta-bisabolene, beta-trans-ocimene and beta-cadinene (source: phytochemistry, 21, 1653, 1982)

The sensorial quality can be described as fresh, pleasant, remotely reminiscent of tangerines

Annex 3

ISO/R 210:1961	Essential oils - Packing
ISO/R 211:1961	Essential oils - Labelling and marking containers
ISO 212:1973	Essential oils - Sampling
ISO 279:1981	Essential oils - Determination of relative density at 20 degr
ISO 280:1976	Essential oils - Determination of refractive index
ISO 356'1977	Essential oils - Preparation of test sample
ISO 590:1981	Oil of brazilian sassafras
ISO 592:1981	Essential oils - Determination of optical rotation
ISO 709:1980	Essential oils - Determination of ester value
ISO 770:1980	Oil of Eucalyptus globulus
ISO 855:1981	Oil of lemon, Italy, obtained by expression
ISO 856:1981	Oil of peppermint, France, Italy, United Kingdom and USA
ISO 875:1981	Essential oils - Evaluation of miscibility in ethanol
ISO 1041:1973	Essential oils - Determination of freezing point
ISO 1202:1981	Essential oils - Determination of 1,8-cineole content
ISO 1241:1980	Essential oils - Determination of ester value after acetylati
ISO 1242:1973	Essential oils - Determination of the acid value
ISO 1271:1983	Essential oils - Determination of carbonyl value - Free hydro
ISO 1272:1973	Essential oils - Determination of phenols content
ISO 1279'1984	Essential oils - Determination of carbonyl value - Hydroxylam
ISO 1342:1988	Oil of rosemary (Rosemarinus officinalis Linnaeus)
ISO 3033:1988	Oil of spearmint (Mentha spicata Linnaeus)
ISO 3043:1975	Oil of pimento berry
ISO 3044:1974	Oil of Eucalyptus citriodora
ISO 3045:1974	Oil of bay
ISO 3053:1975	Oil of grapefruit (obtained by expression)
ISO 3054:1987	Oil of Lavandin abrialis (Lavandula angustifolia P.Miller x L
ISO 3061:1979	Oil of black pepper
ISO 3062:1974	Oil of sandalwood (Eucarya spicata), Australia
ISO 3063:1983	Oil of ylang-ylang (Cananga odorata (Lamark) J D Hooker and T
ISO 3064:1977	Oil of petitgrain, Paraguay
ISO 3065:1974	Oil of Australian Eucalyptus, 80 to 85% cineole content
ISO 3140:1990	Oil of sweet orange (Citrus sinensis (Linnaeus) Obsbeck), obt
ISO 3141:1986	Oil of clove leaf (Syzygium aromaticum (Linnaeus)
ISO 3142:1974	Oil of clove bud
ISO 3143:1975	Oil of clove stem
ISO 3214:1974	Oil of Litsea cubeba
ISO 3215:1974	Oils of nutmeg
ISO 3216:1974	Oil of cassia
ISO 3217:1974	Oil of lemongrass (Cymbopogon citratus)
ISO 3218:1976	Essential oils - Principles of nomenclature
ISO 3475:1975	Oil of aniseed
ISO 3515:1987	Oil of French Lavender (Lavandula angustifolia P, Miller)
ISO 3516:1980	Oil of coriander
ISO 3517:1975	Oil of neroli
ISO 3518:1979	Oil of sandalwood (Santalum album, Linnaeus)
ISO 3519:1976	Oil of lime, obtained by distillation
ISO 3520:1980	Oil of bergamot, Italy
ISO 3523:1976	Oil of cananga
ISO 3524:1977	Oil of cinnamon leaf
ISO 3525:1979	Oil of amyris

ISO 3526:1991	Oil of sage {Salvia lavandulifolia)
ISO 3527:1975	Oil of parsley fruit
ISO 3528:1977	Oil of mandarin, Italy
ISO 3714:1980	Oil of pennyroyal
ISO 3756:1976	Oil of cubeb
ISO 3757:1978	Oil of patchouli
ISO 3760'1979	Oil of celery seed
ISO 3761:1976	Oil of rosewood, Brazil
ISO 3793:1976	Essential oils - Estimation of primary and secondary free alcohol
ISO 3794:1976	Essential oils (containing tertiary alcohols)
ISO 3809:1987	Oil of lime, Mexico (Citrus aurantifolia (Christmann) Swingle
ISO 3848:1976	Oil of Java citronella
ISO 3849:1981	Oil of Ceylon citronella
ISO 4096:1978	Essential oils (containing tertiary alcohols)
ISO 4715:1978	Essential oils - Quantitative evaluation of residue on evaporation
ISO 4716'1987	Oil of vetiver (Vetiveria zizanioides (Linnaeus) Nash)
ISO 4718:1981	Oil of lemongrass (Cymbopogon flexuosus)
ISO 4719:1983	Oil of spike lavender (Lavendula latifolia (Linnaeus fils)
ISO 4720:1992	Essential oils - nomenclature - Bilingual edition
ISO 4724:1984	Oil of cedarwood, Virginia (Juniperus virginiana Linnaeus)
ISO 4725:1986	Oil of cedarwood, Texas (Juniperus mexicana Schiede)
ISO 4727:1988	Oil of palmarosa (Cymbopogon martinii (Roxburgh) W. Watson va
ISO 4728:1992	Oil of wild thyme (Thymus mastichina, Linnaeus)
ISO 4729:1984	Oil of pimento leaf (Pimenta dioica (Linnaeus) Merrill)
ISO 4731:1978	Oil of geranium
ISO 4732:1983	Rectified oil of Eucalyptus globulus Labillardiere, Portugal
ISO 4733:1981	Oil of cardamom
ISO 4734:1981	Oil of mace
ISO 4735:1981	Oils of citrus - Determination of CD value by ultraviolet spectroscopy
ISO 5991:1979	Essential oils - Determination of residue from distillation
ISO 7353:1985	Oil of rosewood - Determination of alpha-terpineol content -
ISO 7355:1985	Oils of sassafras and nutmeg - Detremination of safrole
ISO 7356:1985	Oils of thujone cotaining Artemesia and oil of sage (Salvia 0
ISO 7357:1985	Oil of calamus - Determination of cis-beta-asarone content -
ISO 7359:1985	Essential oils - Analysis by gas chromatography on packed column
ISO 7609:1985	Essential oils - Analysis by gas chromatography on capillary column
ISO 7610:1985	Oil of sandalwood - Determination of santalols content
ISO 7611:1985	Oils of lemon and petitgrain citronnier, and oil of lime
ISO 7660:1983	Essential oils - Determination of ester value of oils
ISO 8432:1987	Essential oils - Analysis by high performance liquid chromatography
ISO 8896:1987	Oil of caraway (Carum carvi Linnaeus)
ISO 8897:1991	Oil of juniper berry (Juniperus communis Linnaeus)
ISO 8899:1991	Oil of lemon petitgrain (Citrus limon (Linnaeus) N L Burman
ISO 8900:1987	Oil of bergamot petitgrain (Citrus aurantium (Linnaeus) ssp.
ISO 8901:1987	Oil of bitter orange petitgrain (Citrus aurantium (Linnaeus)
ISO 8902:1987	Oil of lavandin grosso (Lavandula angustifolia P. Miller x La
ISO 9841:1991	Oil of hyssop (Hyssopus officinalis Linnaeus)
ISO 9842.1991	Oil of rose (Rosa damascena P. Miller)
ISO 9843:1991	Oil of cedarwood (Cupressus funebris Endlicher)
ISO 9844:1991	Oil of bitter orange (Citrus aurantium (Linnaeus) ssp. auran
ISO 9910:1991	Oil of sweet orange - Determination of the total caretenoids

The potential commercial applications of the research

- Essential oils are derived from volatile aromatic compounds found in plants. They are used the food and beverage industry as a source of flavour and aroma, cosmetic industry for fragrances and in the pharmaceutical industry for its functional properties and aromatherapy for the reducing stresses properties. Most of the essential oil used are imported where some can be extracted in Mauritius. The three selected plants namely thyme, Murraya koenigii - "carri poulet", coriander can be directly be put into useage in all above industries.

- The primary markets for the above essential oil are the flavour and fragrance industries which include food companies, hotels and caterers, perfume companies and aromatherapy traders and users.

- The aromatherapy market is a suitable niche in Mauritius for small scale production. However it will require a large amount of market research to determine which essential oils are in demand; agronomic research to determine which crop can be grown and technical research to assist producers in achieving the quality of oil required by these markets. The above extracts are usually blended with other oils in all massage beauty parlours.

- Murraya koenigii - carri poulet oil is a new innovative application; however we must determine the demand or induce its practical use as essential instead of dried leaves in food. We must hence assess the economic potential of producing and marketing this particular oil

Conclusion and highlight questions

The commercial applications of the above research shall streamline issues in the development of the essential oil industry with some the selected plants under research. We have given an overview in pointwise form of the key issues that would influence the success of the essential oil enterprise taking into consideration any oil that need to be developed. These key issues need to be explored in the phase II of the research project

The conclusion and highlights questions are to provide an objective overview of management issues associated with the production and marketing of essential oil.

- **Marketing basics**

A producer of essential oils must be prepared to spend significant amount of time in researching the markets and planning how to access their target markets

Industrial Buyers establish their own quality standards. Producers need to develop loyalties to suppliers of consistent product. The use of test protocols is primarily for verifying the purity of the oil and its characteristics compared to their specific compound they need in the oil.

Marketing activities for a producer of essential oil for the aromatherapy include:

- having frequent business calls with wholesalers, aromatherapist, hotels & caterers, perfume users to develop markets for the product
- maintaining contact with buyers and developing contacts with prospective buyers
- being prepared to deal with several different markets each requiring specific products
- providing samples to buyers i.e. having a small pilot extraction unit for samples

Upon venturing in the essential industry we must be prepared to research the following market issues:

- Which oils are in short supply and which are in over supply?

- Are there any current trends in the use of individual essential oil or do the marketing to promote a potential one becoming trendy?
- Which oils are subject to adulteration?
- What is the agronomic potential of the crops which have a market potential and what best season to buy for extraction?
- What are the strategies for accessing the market?

- **Production Basics**

Producers must be prepared to stay constantly up-to-date concerning agronomic practices, developments in new varieties and new extraction techniques

Agronomic information for crops with economic potential need to be explored and with the help of organisation such as the FARC, on-form research results need to be obtained to best determine the growing techniques that give the best results. Critical production issues are the site selection, adaptability, seedbed preparation, seeding fertilisation, weed control, harvesting, storage and processing, non useage of pesticides that can affect oil quality.

Distillation can also be done by onsite facilities, mobile units that come to the farm or using a particular techniques as essential oil need to be extracted as soonest as possible from harvesting to improve significantly the yield

- **Economic / Financial Basics**

The cost of distilling or extraction the essential oils is a critical cost area. The production process for an individual enterprise need to achieve a balance among the processing capacity, the acres of crop to be harvested or the cost of material to be bought, the processing cost per unit and the quantity the market is prepared to accept.

Producers need to assess carefully the economics of a particular stage before moving to the next stage of development. These stages include:

Establish a small trial plot primarily relying on labour and a small distillation unit. Before going further answers need to be sought;

- Can the plant be grown or can be bought in a constant supply independent of the prices variation during the season?
- What factors will limit the growing ability of the plant? Drought, cyclone....
- What are the main characteristics of the oil to be produced? Major aromatic component of compound sought in oil`

Establish an experimental acreage and using a steam distillation unit. Before going further answers need to be sought;

- What are the optimum fertiliser, irrigation practices, pest control practices?
- What is the optimum time for planting, harvesting and distilling?
- What is the optimum crop size for the processing capabilities available?