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DEVELOPMENT OF THE ESSENTIAL OILS INDUSTRY IN ETHIOPIA

SI/ETH/90/802/11-02

ETHIOPIA

Technical report: Assessment of domestic and international markets for essential oils and related natural products*

Prepared for the Government of the People's Democratic Republic of Ethiopia by the United Nations Industrial Development Organization

Based on the work of S. Jain, Marketing expert in essential oils/ oleoresin products

Backstopping Officer: T. De Silva, Chemical Industries Branch

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* This document has not been edited.

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INTRODUCTION

The project reflects a long standing UNIDO effort to respond to the request of the Ethiopian Government on the development of the essential oils industry in the country.

The project is of a direct support nature and is targeted at providing the National Chemical Corporation of Ethiopia with a high level advice on the development of the essential oils industry.

BACKGROUND INFORMATION

Ethiopia wished to develop agro-industries, as is well known. However, traditional crops such as coffee and cotton face extremely difficult marketing conditions. Hence the urgent need to identify and develop non-traditional agro-industries.

Essential oils have been identified as one such commodity. On the supply side it has been noted that the country has a wide variety of climatic zones and a large rural population that needs employment. As far as demand was concerned a cursory examination indicated that the markets should be available both locally and abroad.

To date the Ethiopian Government has taken several steps to try to develop the industry. The National Chemical Corporation (NCC) has:

(i) Acquired 80-100 hectares of/and for conducting agronomic research. Some of it has already been planted to eucalyptus citriodora, lemongrass and geranium;

(ii) obtained a tractor and a trailer for farm work;

(iii) Been seeking to reactivate an oil processing plant at Wendo Guenet; (in this connexion it should be noted that under an umbrella project DP/ETH/80/013), Industrial Project Development, technical assistance was provided in 1983 to assist in the rehabilitation of this plant).

(iv) Purchased a mobile distillation plant which has already arrived in Ethiopia;

What was lacking and urgently needed to fully supplement NCC's efforts was expertise in regard to agronomy, processing and marketing for the industry;

To overcome this constraint the Ethiopian Government, on an urgent basis, sought technical assistance from UNIDO. The fact that the mobile distilling plant has already arrived in the country only served to emphasize the immediacy of the need.

PURPOSE OF THE PROJECT

Project Objective

To enable Ethiopia's National Chemical Corporation to plan and decide on actions required to successfully operate an essential oil production facility.

POST TITLE: MARKETING EXPERT IN ESSENTIAL OILS/ OLEORESIN PRODUCTS SI/ETH/90/802/11-02

Activities

The expert mission was fielded and was expected to accomplish the following:-

(i) Assess the present situation in regard to existing equipment, availability of raw material and the necessary services and recommend the strategies and mechanisms to be adopted.

(ii) Assess the possibilities available for analytical quality control and recommend measures to be adopted.

(iii) Prepare a comprehensive final report on the development of the essential oils in Ethiopia.

(iv) Presentation of a comprehensive report on the agronomy, marketing and processing of essential oils, consistent with the raw material available in the country, to Ministry of Industry.

JOB DESCRIPTION ATTACHED HEREWITH AS ANNEXURE I.

SUMMARY

The mission took place between 31sr May 1992 and 2nd July 1992 during which time the expert was attached to National Chemical Corporation, Addis Ababa, dedicated to the development of the essential oils industry in Ethiopia.

In collaboration with the counterpart staff of the National Chemical Corporation, the expert carried out the following specific functions:-

1. Assessed the activities initiated by the National Chemical Corporation.

2. Recommended appropriate course of action to be taken in order to substitute imports by local production.

3. Collected world market data and assessed market outlets for the various essentials oils with potential of being produced in ethiopia.

4. Assisted in the determination of plant capacity, the product mix and the production schedule required.

5. Identified important trading houses in major market centres.

6. Identified qualities of essential oils that can be marketed.

7. Identified and described different marketing arrangements common for the essential oil trade.

8. Recommended most appropriate short and long term strategies.

9. Identified sources of supply for obtaining appropriate planting material of known essential oil plants.

10. Advised National Chemical Corporation to enable it to develop agro-industry based on essential oils.

11. Prepared a comprehensive report on the development of essential oil industry in Ethiopia.

Additionally the following activities were performed:-

1. A one week workshop was organized for the staff of the Essential oils section of the National Chemicals Corporation, to educate them about the Fragrance and Flavours Industry.

the detailed programme of the Seminar in attached herewith as Annexure 19

2. A one day workshop was organised for the staff of the following organisations to educate them about the International Commercial and Trading Practices of the Fragrance and Flavour Industry.

The detailed programme of the Seminar is attached herewith as annexure 20 .

3. the industrial uses of essential oils were defined to enable the NCC to understand the very wide scope of the industry and utilize the locally produced oils in local industries.

4. A project profile for the production of Fragrances and Flavours for prepared to serve as a guideline for Ethiopian enterpreneurs.

5. Method for creation of an olfactory Assessment and sensory evaluation laboratory for National and Synthetic Perfumery Materials.

6. To enable the staff of National Chemical Corporation to work at an international level in trading and commercial circles, the Glossary of terms relating to Natural and synthetic perfumery Materials was prepared and explained.

7. A list of standard Books on Essential oils was prepared to enable the National Chemicals Corporation to build up a useful reference library.

8. An update of the Modern Technology used to process and produce essential oils has been prepared to aquaint the staff of National Chemical Corporation with the same.

9. Standard Quality Control procedures were discussed and detailed to enable the National Chemical Corporation to produce essential oils of a quality acceptable in the world market.

10. Agronomical Procedures and practices of essential oil bearing plant crops has been discussed and described to enable the National Chemical Corporation to adopt and cultivates new crops to produce a fresh variety of essential oils with a ready market in the world.

FINDINGS, OBSERVATIONS AND WORK PERFORMED

1. It was found that Ethiopia has a variety of clearly distinct geoclimatic regions in which a large variety of essential oil bearing crops can be cultivated, with substantial export potential and therefore foreign exchange earning.

2. It was observed that some attempts had already been made to do so but without tangidle result, due to a variety of reasons such as lack of experience and information regarding the agronomical practices, quality control procedures and marketing arrangements.

3. To remedy the situation information regarding the code of cultivation practices to be followed, Quality control procedures both instrumental and chemical, and international marketing techniques was imparted to the project authorities namely the National Chemical Corporation.

4. It was found that there was no indigenous production of aroma chemicals and fragrances and flavours - the end products in which essential oils are consumed.

5. It was observed that a viable essential oils industry could be build up if there was a domestic consumption as well in addition to exports.

6. As such to achieve this end, information was imparted regarding:-

(i) Establishment of new essential oil bearing crops.

(ii) Establishment of a facility for the production of Aroma chemicals

(iii) Establishment of a Fragrance and Flavour Research and Development Laboratory.

(iv) Establishment of a facility to produce fragrances and flavours.

(v) Establishment of Applications Laboratories for cosmetics, soaps and related products.

7. It was found that no data regarding the size of the world market for essential oils was available and as such no planning could be done regarding the variety of crops to be planted.

8. It was observed that in the absence of concrete commercial data, the emphasis remained on research and trials, rather than on commercial production.

9. To remedy the situation, comprehensive data on world market in essential oils in terms of exports, imports and production was provided to the project authorities.

10. It was found that the project authorities did not have complete information regarding the important Trading Houses in major market centres and hence were unable to undertake proper marketing.

11. Accordingly complete details about the major trading houses was provided.

12. It was found that the project authorities were sometimes unaware of the exact qualities that are traded in the world market and were thus unable to get a proper response from the customers.

13. As each details of quality Assessment and standard specifications for oils of Lemon gress and Eucalyptus were provided and it was explained that exports would be possible if products conformed to the said international standards.

14. Since the Essential oils Industry is agriculture based, both short term and long term strategies are required to be formulated to plan the growth of the industry.

15. It was found that such a plan and perspective was lacking and the same was accordingly prepared for consideration and implementation by the project authorities. The short and long term strategies spelt out by the expert concerned themselves with the following aspects:-

(1) Role of Research and Development in the Essential oils Industry, especially in the following fields:-
   (a) Screening of wild flora.
   (b) Improving yield potential of Essential oil crop plants of established value.
   (c) Improvement of Processing Technology
   (d) Quality Assessment Methods.
   (e) Prospects for Development of Essential oil Bearing Crops by Genetic Manipulation.

16. In was observed that the National Chemical Corporation required guidance regarding the steps to be taken to develop the essential oils industry in Ethiopia. As such the various aspects of a comprehensive development programme were outlined and discussed. The programme concerned itself primarily with the following aspects:-

(a) Cultivation aspects of Aromatic plants
(b) Technological Aspects
(c) Managerial Aspects
(d) Storage and Marketing of produce
(e) Creation of Support Agencies and Regulatory Assistance.
(f) Start-up of collaboration among developing countries.

17. It was found that the staff of the National Chemical Corporation would be better equipped to cope with the demands of the Essential Oils Industry in a world context, if they could be trained in the various aspects by the expert.

18. Accordingly two seminars were organized; one for the staff of the National chemical Corporation and another one which included technical personnel from the Addis Ababa University also.

The topics covered int he seminar were as under:-

1. Fragrances and Flavours
   a) A perspective of the World Industry
   b) Uses of Fragrances and Flavours and
2. Technology of Fragrances, Flavours and Essential oils - ambit of skills required.

3. Raw Materials used in Fragrances and Flavours.
   a) Variety
   b) Production.
4. Synthetic and Natural Materials
   - Advantages and Disadvantages
5. Essential oils, Resinoids and oleoresin
6. Quality control and Olfactory Assessment.
7. Use of Olfactory sense for creation.
8. World wide trade in Essential oils.
9. Establishment of Essential oils and related industries.
10. Marketing of Essential oils; Trading and Commercial Practices followed in the World Market.

18. It was found that Ethiopia had no indigenous Fragrance and Flavour Industry and all its requirements were met by imports. As a consequence thereof, there was no domestic market for essential oils at all. Since no industry can subsist on exports alone in isolation from the domestic industry, it was felt that to establish a viable essential oils industry in the country it would be necessary to have a Fragrance and Flavours Industry also.

19. Accordingly for the guidance of the project authorities, a project profile for the Production of Fragrances and Flavours was prepared. The project profile covered the following aspects:-

a) Fragrance Applications.
b) Flavour Applications
c) Marketing Feasibility and Scope.
d) Variety of Products
e) Raw Materials
f) Processing Method, Equipment and Quality Control.
g) Technical Feasibility
h) Project aerometers for a Typical Installation.

20. It was found that the staff of the National Chemical Corporation were unaware of Olfactory Assessment as a vital method for Quality Control.

21. Accordingly full details were provided for the creation of an Olfactory Assessment and sensory Evaluation Laboratory for National and Synthetic Perfumery Materials.

22. It was observed that the technicians in the essential oils industry were not fully conversant with the terminology used internationally in the trade of Natural and synthetic perfumery materials.

23. As such a comprehensive list of such terms was prepared and explained to the project authorities.

24. It was observed that in the absence of standard literature

regarding essential oils, Research and Development and Quality Control work was being hampered.

25. As such a comprehensive list of such books was prepared and handed over to project authorities.

26. It was observed that although the National Chemical Corporation was producing essential oils namely Lemongress oil and Eucalyptus citriodora oil, the technology being used was old and needed updating.

27. As such a review of the Modern Technology used for production of Essential Oil was provided to the technical staff of the project authorities.

28. It was observed that the technical staff of the National Chemical Corporation while being familiar with Quality Control Procedures in general, did not have precise information regarding the exact methods to be used and as such Modern Quality Control Procedures were provided and explained to them.

29. It was observed that variety and extent of essential oil hearing crops being cultivated in Ethiopia was rather limited and such marketing of a limited quantity and variety posed a problem due to tne uneconomic operation of the farms.

30. to remedy the situation, complete details regarding the agronomic practices to be followed in the case of the following crops recommended for cultivation were provided:-

a) Citronella Java
b) Lemongrass
c) Palma Rosa
d) Eucalyptus Citriodora
e) Eucalyptus Globulus
f) Geranium
g) Mentha Arvensis
h) Mentha Piperita
i) Mentha Citrata
j) Mentha Spicata
k) Rosa Demescena
l) Sweet Basil
m) Vetiver oil

CONCLUSIONS

1. It was concluded that ethiopja must take full advantage of its clearly distinct geoclimatic regions and cultivate the following essential oil hearing crops:

i) Citronella Java
ii) Lemongrass
iii) Palma Rosa
iv) Eucalptus Citriodora
v) Eucalyptus Globlus
vi) Geranium
vii) Mentha Arvensis
viii) Mentha Piperita
ix) Mentha citrata
x) Mentha Spicata
xi) Rosa Damascena
xii) Sweet Basil
xiii) Vetiver oil

It was concluded that this would result in large foreign exchange earnings, provided the correct agronomical practices, quality control procedures and marketing arrangements were followed.

2. It was concluded that to build up a viable export industry in essential oils, it was necessary to create a domestic market for essential oils and to this end set up facilities to manufacture aroma chemicals, fragrances and flavours and also to conduct suitable and practical research in these fields. Such a step will give the additional benefit of Import substitution.

3. It was further concluded that since essential oils, aroma chemical, fragrances and flavours were themselves intermediate products in the manufacture of products such as soaps, detergents, cosmetics, toiletteries, bakery products, confectionery and beverages, R & D facilities and applications laboratories should be built up where know how regarding these products could be transferred to willing entrepreneurs.

4. It was concluded that through an appropriate agency, data regarding the world trade including price trends should be made available on a regular basis to organisations involved in the essential oils trade in Ethiopia so that planning may done regarding the variety of crops to be planted.

5. It was concluded that in the interest of creating regular exports in essential oils, contact should be established with the important trading houses in major marketing centres. This would help is not only exporting the essential oils produced in Ethiopia but also help in the import of raw materials required for the domestic industry at the best prices.

6. It was concluded that all production destined for export, should be in accordance with the accepted International standards and specification so that the essential oils produced in Ethiopia may become acceptable in the world market

and also may be sold at the ruling international price so as to yield the most economic return to the industry.

7. It was concluded that a short and a long term strategy is necessary for the development of the essential oil industry in Ethiopia and that such a strategy should encompass the role of Research and Development in the following fields:-

a) screening of wild flore.
b) Improving Yield potential of essential oil crop plants of established value
c) Improvement of processing technology
d) Quality assessment methods.
e) Prospects for Development of Essential oil bearing crops by genetic manipulation.

8. It was concluded that a comprehensive and concrete plan of action was required to develop the essential oils industry in Ethiopia and that such a programme should concern itself with the following aspects:-

a) Cultivation Aspects of Aromatic plants
b) Technological Aspects.
c) Managerial Aspects
d) Storage and marketing of produce
e) Creation of support agencies and regulatory assistance.
f) Start up of collaboration among developing countries.

9. It was concluded that the project staff as well as potential entrepreneurs required regular and comprehensive training in the essential oils, Aroma Chemical Fragrance flavour industries because of lack of any existing industry in the country and consequent lack of trained and experienced personnel to run the industry.

10. It was therefore further concluded that a full fledged Technical Assistance Programme under the aegis of UNIDO/UNDP was required to establish the industry on a sound footing and provide the requisite inputs such as:-

a) Modern equipment for production quality control and R & D
b) Training of personnel & quality control in production, R & D
c) know-how regarding manufacturing and quality control procedures.
d) Exposure to international trade
e) compilation of literature.
f) International marketing tie-ups.

RECOMMENDATIONS:

Keeping in view the Findings, observations, work performed and conclusions, the following recommendations addressed to the project authority the National Chemical Corporation and the concerned ministry i.e. The Ministry of Industry are hereby made:-

1. It is recommended that urgent steps be taken to begin the cultivation of the following essential oil bearing crops in the appropriates geo-climatic area:-

i) Citronella Java
ii) Lemon grass
iii) Plama Rosa
iv) Eucalyptus citriodora
v) Eucalyptus Globlus
vi) Geranium
vii) Mentha Arvensis
viii) Mentha piperita
ix) Mentha citrata
x) Mentha spicata
xi) Rosa Damascena
xii) Sweet Basil
xiii) Vetiver oil

2. It is recommended that through the media of support Agencies and Regulatory Assistance, incentives and opportunities should be provided to potential entrepreneurs to initiate the creation of a domestic industry in Ethiopia manufacturing not only essential oils but also Aroma Chemicals, Fragrances and Flavorous such that this industry may become nucleus of the growth in this area and cater to the requirements of the export as well as the domestic markets, in the process generating foreign exchange both by exports and by Import substitution.

3. It is recommended that comprehensive research and development facilities should be set up to provide back up to the industry in the following areas:-

a) Essential oils:-

i) Screening of Wild Flora.
ii) Improving Yield Potential of Essential oil crop plants of established value.
iii) Improvement of Processing Technology
iv) Quality Assessment Methods.
v) prospects of Development of Essential oil crops by genetic manipulation.

b) Aroma Chemicals

i) Identification of the aroma chemicals that can be produced as Isolates and Derivatives from Ethiopian Essential Oils.
ii) Quality Assessment Methods.

c) Fragrances and Flavours.

i) Quality Assessment Services based on sensory Evaluation to both the Essential oil and Aroma chemicals sectors.
ii) Quality Assessment Services based on sensory Evaluation to both Fragrance and Flavours Industries
iii) Creation of new fragrances and flavours to suit the requirements of the Ethiopian market, using particularly locally produced new materials.
iv) Conduct of Training courses for entrepreneurs and technicians in the fields of Essential oils, Aroma Chemicals, Fragrances and Flavours.

d) Applications Laboratory:

i) To develop commercial methods of manufacture of soaps, cosmetics, toiletteries, detergents, bakery products, confectionery and beverages.
ii) To make available on a turn key basis this know how to willing entrepreneurs.
iii) to provide Quality Assment Services to this sector.
iv) To keep abreast of International Developments in Consumer Products of this nature and update the Ethiopian entrepreneurs accordingly.

4. It is recommended that a comprehensive Data Bank be created in relation to the Essential oils, Aroma chemical, Fragrance and Flavour Industries which will keep on record and update all published information regarding the Technical and Commercial aspects of the industry.

5. It is recommended that a comprehensive plan of Action should be implemented urgently to develop the Essential oils sector and that this plan should concern itself with the following aspects:-

a) Cultivation Aspects of Armatic Plants.
b) Technological Aspects
c) Manegerial Aspects
d) Storage and Marketing of produce
e) Creation of Support Agencies and Regulatory Assistance.
f) Start-up of collaboration among developing countries.

6. It is recommended all the aforementioned recommendations should be implemented under the aegis of a UNIDO/UNDP Technical Assistance Programme and that such a programme should cover the following aspects of the industry:-

a) Agronomy -Cultivation Improvement and Extension of Essential oil bearing crops.
b) Processing Technology: Production of Essential Oils using modern technology.
c) Quality Assessment Methods: To ensure production of essential oils as per internationally acceptable specifications and standards.
d) Development of process know how for production of isolates and Derivatives using locally produced essential oils.
e) Development of sensory evaluation capabilities to service the essential oil, aroma chemicals and fragrance and flavour industries.
f) Conduct of appropriate Training programmes for Entrepreneurs and Technicians.
g) Establishment of an adequate Data Bank.

ANNEXURE 1

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PROJECT IN THE GOVERNMENT OF ETHIOPIA

JOB DESCRIPTION

Post Title : Marketing Expert in Essential Oil/Oleoresin Products

Duration : 2 man/months

Date required: ASAP

Duty Station : Addis Ababa with internal as well as international travels

Purpose of Project : Assessment of domestic and international markets for essential oils and related natural products, etc and recommendation of short and long term strategies for the development of industries for the processing of same.

Duties : The expert will specifically by expected to:-

1. Assess and comment on activities in progress initiated by NCC.

2. Collect domestic market data and recommend appropriate course of action to be taken in order to substitute imports by local production.

3. Collect world market data from appropriate sources such as world market statistical abstracts, specialized institutes, trading houses etc and assess market outlets for :

   Lemongrass Oil
   Citronella Oil
   Geranium Oil
   Vetiver Oil
   Patchouli Oil
   Eucalyptus (Citriodora, Globulour, etc) Oil
   Basil Oil
   Lime Oil and other similar products

   Export market assessment should include demand and supply situation, price trends, competition and future demand and price outlooks.

4. Assist in the determination of plant capacity and the product mix and the production schedule required.

5. Identity important houses in major market centres and recommend the most feasible types and qualities of essential oils that can be marketed.

6. Identify and describe different marketing arrangements common for the essential oil trade and recommend the most appropriate with short and long term strategies.

7. Assist NCC in obtaining appropriate and authentic varieties/cultivars of known essential oil plant species from growers aboard.

8. Advise NCC on the general course of action to be taken in order to develop agro-industry based on essential oils in the country.

9. Assist in the preparation of the comprehensive report on the development of the essential oil industry in Ethiopia.

10. Perform any other duties in connection with the study of the project within his competence.

Qualification:

The candidate should have a degree in business administration, economics or related fields and should be well experienced with a considerable working knowledge of the essential oil market including relative influence of major trading houses.

Language: English

Background and Information:

Ethiopia wishes to develop agro-industries, as is well known, however, traditional crops such as coffee and cotton face extremely difficult marketing conditions. Hence the urgent need to identify and develop non-traditional agro-industries.

Essential oils have been identified as one such commodity. On the supply side it has been noted that the country has a wide variety of climatic zones and a large rural population that need employment. As far as demand is concerned a cursory examination indicates that the markets should be available both locally and abroad.

To date the Ethiopian Government has taken several steps to try to develop the industry. The National Chemical Corporation (NCC) has:-

1. Acquired 80-100 hectares of/and for conduction agronomic research. Some of it has already been planted to eucalyptus citriodora, lemongrass and geranium.

2. Obtained a tractor and a trailer for farm work.

3. Been seeking to reactivate on oil processing plant at Wendo Guenet; (In this connection it should be noted that under an umbrella project DP/ETH/80/013), Industrial Project Development, technical assistance was provided in 1983 to assist in the rehabilitation of this plant).

4. Purchased a mobile distillation plant which has already arrived in Ethiopia.

What is lacking and urgently needed to fully supplement NCC's efforts is expertise in regard to agronomy, processing and marketing for the industry.

To overcome this constraint the Ethiopian Government, on an urgent basis, sought technical assistance from UNIDO. The fact that the mobile distilling plant has already arrived in the country only serves to emphasize the immediacy of the need.

v SUDHIR JAIN

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ANNEXURE 2

NAMES OF PEOPLE MET DURING THE COURSE OF THE ASSIGNMENT

1. DR. TADELE WORKU,	NATIONAL CHEMICAL CORPORATION.
2. DR. MADEHIN ZOWDU,	NATIONAL CHEMICAL CORPORATION.
3. DR. MAMO HSEPDOM,	NATIONAL CHEMICAL CORPORATION.
4. MR. MULUGETA CHANE,	NATIONAL CHEMICAL CORPORATION.
5. MR. FIKRE YEFTU, (DEPUTY GENERAL MANAGER)	NATIONAL CHEMICAL CORPORATION.
6. MR. ASRAT BULBULA (GENERAL MANAGER)	NATIONAL CHEMICAL CORPORATION.
7. MR. SAMUEL LIBON	NATIONAL CHEMICAL CORPORATION.
8. MR. YITBAREK ALEMU	NATIONAL BEVERAGE CORPORATION.
9. MRS. YALEMBERHAN	NATIONAL LIQUOR FACTORY.
10. MRS. KOKEB	NATIONAL LIQUOR FACTORY.
11. MR. KASSAHUN	MERTI FRUIT CANNING FACTORY.
12. MR. ABEBE	MERTI FRUIT CANNING FACTORY.
13. MR. BEKELE TSEGHYE	REPPI SOAP FACTORY.
14. MR. SOLOMON MEBRAHTU	INDUSTRIAL CHEMIST.
15. MR. TADESSE BAYABIL	PRIVATE ENTREPRENEUR.
16. MR. MULAT ABEGAZ	MINISTRY OF INDUSTRY.

ANNEXURE 3

ACTIVITIES INITIATED BY NATIONAL CHEMICAL CORPORATION

1. Ethiopia has a variety of clearly distinct geoclimatic regions in which various types of exotic and indigenous essential oil bearing plants can be grown on a commercial scale with the aim of diversifying products which coulo contribute positively towards the saving and earning of foreign exchange as well as provide a large base for the indigenous industry ti grow using only domestic resources.

2. The development of agro-industries based on essential oils is not only creating additional employment but also benefitting the rural sector populations with new technological inputs. The industry is utilising rural sector participation in cultivation and harvesting of the raw materials and to some extent in field distillation activities.

3. The National Chemical Corporation has since 1979 been attempting to fulfill basic requirements such as making available suitable planting material in quantity that is sufficient to warrant industial production , relevant technology for distillation, facility for quality assessment, know -how in terms of marketing practices etc. and conducting studies and aquiring land for practical trials so as to initiate and develop an essential oil industry.

4. There is an existing essential oils producing plant at WENDO GUENET, some 15 km fro Shashemene and about 265 km south of ADDIS ABABA. It was established in 1967 and had been operated upto 1974.It remained closed from 1974 to 1987 when the NATIONAL CHEMICAL CORPORATION started renovating and rehabilitating the plant.

5. The NATIONAL CHEMICAL CORPORATION has already aquired 80-100 hectares of land in the surroundings of the plant and has also started growing Eucalyptus citriodora, Lemongrss and Geranium with the aim of covering eventually all the available land except for a few hectares of land to be utilised for conducting agronomic research. Currently experimental distillations are being carried out at Wendo Guenet using Eucalyptus citriodora grown at the WENDO GUENET INSTITUTE OF FORESTRY and Lemon grss from its own field.So far 25 hectares of Lemongrass and 40 hectares of Eucalyptus citriodora have been planted. More than 2000 kilos essential oils were produced in 1990-91.It is expected that some 15000 kilos of essential oils would be produced each year, if not more.
However, in actual fact, since 1990-91 no production has taken place.

6. THE WENDO GUENET ESSENTIAL OILS FACTORY project has the following facilities:

- two stills of 500 and 300 kilos capacities with loading and unloading hoists.The 300 kilos still is incorporated with a firewood boiler.
- one condenser
- florence flask separator
- three storage tanks (one cubic meter each)

Moreover, a tractor with trailer has been purchased for farm work and transporting of raw materials. There are nine permanent employees including an agriculturist, an agronomist and a chemist.The number of

farm workers though variable with the season, during the last planting months averaged 85. It is expected that a minimum of 25 farm and factory workers would get permanent job opportunities in the factory.Housing and office facilities have been provided for the permanent and skilled workers assigned at Wendo Guenet.Investment costs and expenses so far incurred by the National Chemical Corporation of Ethiopia amount to over 330,000 Birr (US $ 165,000/-).

7. The National Chemical Corporation has a short term and a long term programme concerning the agro-industry.The immediate activities are the rehabilitation of the Wendo Guenet plant and growing of selected essential oil bearing plants at different agro-ecological zones on experimental plots and conduct agronomic and process research in co-operation with the relevant organisations and institutions.A mobile distillation plant has already been purchased and it is expected to facilitate these activities.Depending on the results of the research work, a national network of essential oil plantations and distillation units would be systemetically developed in the suitable agro-ecological zones.Outgrowers supply schemes would also be established.Simple distillation technology will also be developed and transferred to the peasants.Finally an essential oils refining unit/secondary processing plant would be established in the country when the production level of crude oils would be adequate for such activity.

8. The National Chemical Corporation is conducting thorough market research in conjunction with the development of the agro-industry in order to identify the varieties of essential oil bearing plantsthat have the highest economic contribution to make towards the development of the country within the limits of the availability of suitable agro-ecological zones for selected varieties/cultivars.

9. The prime target at present is the aquisition of authentic cultivars/varieties of essential oil bearing plants, technical literature and laboratory equipment together with the training of the manpower.The achievement of these targets will greatly enhance the development of this sector.

10. To achieve the above cited aims UNIDO's technical assistance is being obtained im marketing, agronomy and technology of essential oils and related facilities.

THE FOLLOWING ACTIVITIES ARE CURRENTLY IN PROGRESS:-

A. Upgrading of the Wendo Guenet Essential Oils Plant into a National Research Development Centre for essential oils.

B. Identification of suitable agro-ecological zones for planting varios essential oil bearing plants.

C. Determination of the marketibility of essential oils selected in conjunction with the various potentially suitable regions of the country.

D. Preparation of a final comprehensive report for the development of the essential oils sector in Ethiopia.

THE AFOREMENTIONED ACTIVITIES ARE TARGETTED TO ACHIEVE THE FOLLOWING ENDS:-

A. Establishment of a National Research and Development Centre at Wendo

Guenet, purchase of laboratory equipment, provision of publications related to the subject matter and aquisition and introduction of new essential oil bearing plant varieties/cultivars.

B. Identification of a minimum of three agro-ecological zones.

C. Identification of markets and product types and determination of capacities.

D. Preparation of a comprehensive final report on the development the essential oils industry in Ethiopia.

ANNEXURE 4

COMMENT ON ACTIVITIES INITIATED BY THE NATIONAL CHEMICAL CORPORATION

The Wendo Guenet Essential Oils Project was visited by the Expert and all the activities being carried out at the site were examined in detail with a view to transforming the same into a productive unit.

The following steps are required to be taken to establish the working of the said unit on a sound commercial basis:-

1. Collection of Planting Material

At present the following major planting materials have been collected in the nursery being maintained at the site:-

Eucalyptus citriodora
Eucalyptus globulus
Geranium
Cymbopogon citratus (Lemongrass, West Indian)
Local Lemongrass (Palmarosa, Ethiopian)
Thyme
Basils, Various
Marjoram
Ginger
Turmeric
Lipia citriodora
Rosemary
Vetiver
Fennel
Coriander
Artemesia
Parseley
Rue
Mentha arvensis
Mentha piperita
Mentha spicata
Jasmine
Sage

In order to have the best variety/cultivar of any given crop available for planting, it is necessary to collect planting material of the aforementioned essential oil bearing plants from the existing and established sources of these crops, especially those which are to be chosen for extensive planting and intensive cultivation.

Since the yield and type of oil obtained from any given type and variety of planting material depends on local conditions such as soil, climate and harvesting practices and because different varieties of essential oil bearing plants behave diferently under any given set of conditions, it is necessary to establish on the basis of systemetic trials the particular variety/cultivar of every essential oil bearing plant which is chosen for multiplication and cultivation.

2. Selectionof Crops for Extending/Establishing Cultivation

Keeping the requirements of the international market in mind,

it is necessary to extend or establish, cultivation of only certain selected crops which have the greatest potential of sale in the world market.This is essential because Ethiopia is not in a position to produce any unique essential oil and hence must compete in the world market with other major producers of essential oils such as CHINA, INDIA, RUSSIA,INDONESIA, BULGARIA, TURKEY, GUATEMALA BRAZIL AND PARAGUAY.

Based on this market potential it is suggested that priority be assigned to the following crops in the order mentioned for the purposes of extending/establishing cultivation:-

Geranium (Pelargonium graveolens)
Palmarosa (Local Lemongrass--Cymbopogon martini, Stapf., motia)
Coriander (Corianderum sativum)
Spearmint (Mentha spicata)
Sage (Salvia officinalis)
Rosemary (Rosemarinus officinalis)
Basil (Ocimum basilicum)
Eucalyptus citriodora
Peppermint(Mentha piperita)
Thyme (Thymus vulgaris)

3. Establishment of Trial Plots

In order to examine and define the qualities of the essential oils that will be yielded by the aforementioned crops, it is necessary that from the nursery the cultivation should be extended to trial plots of half an hectare each so that pilot scale production of those particular essential oils may be carried out and the essential oil so produced may be tested for quality by internationally accepted methods and the same may also be sampled to prospective buyers after quality assessment has been completed.

The suggestions in this regard are as follows:-

A. Planting material from the nursery should be propagated in trial plots of half an hectare each so as to produce at least one to three kilos of oil at a time in the 300 litre charge capacity steam distillation still.

B. Such propagation of planting material should be on the basis of the order of priority already defined.

C. Cultivation on a Commercial Scale

Cultivation on a commercial scale of any given crop should only be started after the oil obtained from the production done on the trial plots has passed all the relevant quality control tests and has subsequently been approved by buyers as well. It must be borne in mind that all essential oils required to be sold commercially have to be produced in accordance with internationally accepted standards of quality and as such selection of planting material and cultivation have to be so arranged so as to yield oils of an acceptable quality.

THE SUGGESTIONS IN THIS REAGARD ARE AS FOLLOWS:-

A. Planting materials cultivated on trial plots which have yielded essential oils of a commercially accepted quality should only be taken up for cultivation on an extensive scale.

B. A minimum of four to five crops should be chosen so as to produce a suitable mix of saleable essential oils.

It is necessary to have a mix of crops because in the world market essential oils are treated as commodities and as such the business of producing and selling essential oils has a cyclical nature in terms of yield as well as the price obtained.

A mix of crops tends to minimise the risks arising out of fluctuations and helps to earn a stable average income which is the first requirement of any commercially viable operation.

5. Pilot Plant Production Unit

It was found that both the steam distillation units existing at the Wendo Guenet Project site are fully operational.However some additional equipment is required from the long term point of view if the units are to be operated on a commercial basis.

THE COMMENTS/ OBSERVATIONS / SUGGESTIONS IN THIS REGARD ARE AS FOLLOWS:-

A. Two steam distillation units of French origin are installed at the site; one of 300 litre charge capacity and the other of 500 litre charge capacity.

B. Both the units are fully operational.

C. However it was observed that untreated water was being used to generate steam both in situ and in the external boiler.

It must be pointed out that on continuous usage, scaling in the steam coils is inevitable and when this happens the units will become inoperational due to choking of the passages through which steam passes.

To remedy this it is necessary to install a Demineralised Water Plant to provide feed water for the steam generation systems.This will ensure that scaling does not occur in the steam coils of the boilers and will thus substantially prolong the operational life of the equipment.

6. Quality Control and Development Activities

The existing laboratory facilities at the project site are inadequate from the point of view of a commercial unit. The on-site laboratory has to carry out the following tasks:-

A. Distillation of small quantities of essential oils from material obtained from the nursery.

B. Identification and Characterisation of all such oils and their constituents.

C. Physio-chemical analyses of essential oils obtained from trial plots and regular cultivation.

D. Grading of such essential oils according to standards accepted and used in the international trade.

FOR FULFILLING THESE OBJECTIVES, THE FOLLOWING FACILITIES HAVE TO BE PROVIDED IN THE LABORATORY:-

A. Properly trained personell to look after the agronomic, engineering and chemistry aspects of the production.

B. Equipment for the production of small quantities of essential oils. To this end, the existing Sample Production Unit should be suitably modified so as to remove the design defects existing at present. Further, laboratory glass distillation equipment consisting of Cleavenger Units should be provided to take care of the day to day work.

C. All instruments, equipment and reagents required for conducting the required physio-chemical analyses, as detailed elsewhere in the report should be provided.

D. A full set of standard samples should be available in the laboratory for the purposes of identification and standardisation of components and oils.

E. A full set of International Standards and Specifications should be available in the laboratory to facilitate the grading of oils.

ANNEXURE 5

DOMESTIC MARKET DATA AND CURRENT MARKET SITUATION

The situation as existing in the market today in Ethiopia was examined and the following are the findings and conclusions:-

1. Production of Essential Oils

The following crops are planted to the extent indicated below at the Wendo Guenet Project site:-

	Area Planted	Production p.a.
A. Eucalyptus citriodora	40 hectares	5000/7000 kilos
B. Lemongrass, W.I.	25 hectares	2500 kilos

THE AFOREMENTIONED AREAS ARE PHYSICALLY UNDER THE CROPS BUT THE DISTILLATION OF OILS IS NOT TAKING PLACE. HENCE THE QUANTITIES MENTIONED ONLY INDICATE THE POTENTIAL FOR PRODUCTION.

Apart from the two essential oils bearing plants mentioned above there is no other cultivation of such plants and consequently no production of any essential oils is actually taking place at present.

2. Production of Spice Extracts

A Spice Extraction Factory processing mainly Chillies has been in existence since 1969.

The present status of the unit is as under:-

A. Range of Products: Chillies Oleoresin and Paprika Oleoresin

B. Annual Capacity: 155 Metric Tonnes (Installed)

115 Metric Tonnes (Operative)

C. Actual Production: 36 Metric Tonnes (Average Annual Production)

D. Sales: Entire production manufactured under contract.

E. Price: US $ 60.00 per kilo for non-pungent colour portion sold as Paprika Oleoresin

US $ 20.00 per kilo for pungent portion sold as Chillies Oleoresin

F. Current Status: Capacity remains unutilised due to shortage of fresh chillies. Procurement of chillies at ruling market prices is not possible due to the very high market price of fresh chillies which is four times

the price at which production is economical and on the basis of which the existing contracts were established. From time to time the diference between the market price and the break-even/economical price is provided by the Government as a subsidy to enable the factory to remain in production.

As such under the current circumstances production takes place only when a subsidy is provided by the Government.

G. Main Markets: USA, Japan, Germany

H. New Products: Processing of Ginger, dried is being tried on a trial basis.

3. Production of Citrus Oils

A large citrus fruit processing plant exists at Merti,about 160 kms south east of Addis Ababa. The plant is equipped to produced citrus juices, marmalades, squashes. The plant has captive plantations of citrus fruits spread over an area of 1200 hectares which provide different varieties of citrus fruits through out the year to the processing factory.

As is usual in the citrus fruits processing industry, the processing plant is designed in such a manner that the essential oil of the particular citrus fruit being processed at any given time can be as obtained as a by product during the processing.

However at present no citrus oils are being produced because there is no domestic demand for this item. Furthermore at present during the processing of citrus fruits no distinction is made between the various varieties of citrus fruits. The essential oil content of the citrus fruits is at present allowed to mix with the juice and is not separated.

The Merti fruit processing factory has a capacity to process 900 to 1000 metric tonnes of citrus fruits annually and obtained as a by product 3 to 5 metric tonnes of citrus oils.

.. Production of Isolates and Derivatives of Essential Oils

There is no local production of such products in the country at present.

5. Production of Fragrances and Flavours for Industrial Use

There is no production of such products in the country at present.

6. Import of Fragrances and Flavours for Industrial Use

Quantity	Value
300 Metric Tonnes	US $ 1,000,000

These figures include the quantity and value for imports of beverage concentrates imported by multinational companies.

7. Prospects for Future Development

Based on the establishment of an indigenous essential oils industry, the prospects for establishing an Import Substitution Industry are good provided the requisite know how can be made available to the concerned entrepreneurs through the appropriate channels.

ANNEXURE 6

DETAILS OF COURSE OF ACTION TO BE TAKEN IN ORDER TO SUBSTITUTE IMPORTS BY LOCAL PRODUCTION

The recommendations made by the expert have been made on the basis of the present status, activities and future potential of the essential oils industry in Ethiopia.

In order to be able to achieve its full potential and contribute its maximum services to the Fragrance and Flavour Industries in Ethiopia the following recommendations have to be implemented:

1. Establishment of new essential oil bearing crops such as Geranium, Palmarosa, Coriander, Spearmint, Sage, Rosemary, Basil, Eucalyptus citriodora, Mentha piperita and thyme.

The cultivation of essential oil bearing plants for the purpose of utilising them as a basis of a modern essential oils industry, requires research experiece in a wide spectrum of scientific and technological disciplines. These could be broadly enumerated as follows:

A. Scientific: Agronomy, taxonomy, genetics, plant pathology, entomology, phytochemistry, soil sciences, plant physiology, analytical chemistry and sensory evaluation.

B. Plant design, process engineering, and metallurgy.

The cultivation of essential oil bearing plants requires experience in the fields of agronomy and cultural practices peculiar to each crop, pest control mechanisms, fertiliser requirements, crop diseases and the selection of strains that would yield oils, olfactorily acceptable to a perfumer/flavow Products: Processing of Ginger, dried is being tried on a trial basis.

3. Production of Citrus Oils

A large citrus fruit processing plant exists at Merti,about 160 kms south east of Addis Ababa. The plant is equipped to produced citrus juices, marmalades, squashes. The plant has captive plantations of citrus fruits spread over an area of 1200 hectares which provide different varieties of citrus fruits through out the year to the processing factory.

As is usual in the citrus fruits processing industry, the processing plant is designed in such a manner that the essential oil of the particular citrus fruit being processed at any given time can be as obtained as a by product during the processing.

However at present no citrus oils are being produced because there is no domestic demand for this item. Furthermore at present during the processing of citrus fruits no distinction is made between the various varieties of citrus fruits. The essential oil content of the citrus fruits is at present allowed to mix with the juice and is not separated.

The Merti fruit processing factory has a capacity to process 900 to 1000 metric tonnes of citrus fruits annually and obtained as a by product 3 to 5 metric tonnes of citrus oils.

4. Production of Isolates and Derivatives of Essential Oils

There is no local production of such products in the country at present.

5. Production of Fragrances and Flavours for Industrial Use

There is no production of such products in the country at present.

6. Import of Fragrances and Flavours for Industrial Use

Quantity	Value
300 Metric Tonnes	US $ 1,000,000

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7. Prospects for Future Development

Based on the establishment of an indigenous essential oils industry, the prospects for establishing an Import Substitution Industry are good provided the requisite know how can be made available to the concerned entrepreneurs through the appropriate channels.

ANNEXURE 7

ASSESSMENT OF POTENTIAL AND ACTION PLAN FOR SETING UP AN AROMA CHAMICALS MANUFACTURING FACILITY AT NATIONAL CHEMICAL CORPORATION TO SERVICE THE ETHIOPIAN INDUSTRY.

Definition of Aroma Chemicals:

Single defined chemical compounds with odour and/or flavour properties inclusive of mixtrures of isomers or compounds of related structures. Such aroma chemicals are used on the basis of the odour/flavour characteristics and need not necessarily by free from by-products arising during production.

Use of Aroma Chemicals:

These are not intended for use on their own but are blended together in defined proportions along with natural raw materials such as essential oils, absolutes, concretes and resinoids but not necessarily so, to produce fragrances and flavours which find use in a host of household, personnel and industrial products.

Present Status of the Industry in Ethiopia

Household, personnel and industrial products:

The products listed in Annexure are made in Ethiopia

Demand is forecast to grow in the 90's.

Fragrance and flavour industries:

There are no indigeneous Ethiopian units

Role of multinational units:

Because of the lack of local units in this business such units corner the total market.

Handicaps in the growth of local industries:

No raw materials worth the name, intended for use in the fragrance and flavour industries, are produced in Ethiopia.

Consequences thereof:

Potential local manufacturers of Fragrances and Flavours are deprived of easy access to basic raw materials and are thus put to a disadvantage vis-a-vis the multinational manufacturers who have their own captive factories for raw materials. Also since these companies are more interested in selling fragrances and flavours, the raw materials that are offered for sale are offered exhorbitantly high prices to deter other manufacturers from entering this field.

The growth of local industry is throttled by the multinational companies.

Step required to be taken to remove the aforementioned handicaps:

1. A research and development cum production centre for aroma chemicals required by the frangrance and flavour industries should be set up to service the Ethiopian industry.

2. The variety of raw materials that can be produced in Ethiopia and for which the know how can be developed with the help of international experts should be identified.

3. The variety of basic chemicals readily available in Ethiopia that can be utilised for the production of the requisite aroma chemicals should be identified.

4. A suitable research centre to undertake the research and development CUM production work should be identified.

Steps already taken to fulfill the aforementioned tasks:

1. The Research and Development Centre has been identified, namely, the Essential Oils Research Group of the National Chemicals Corporation.

2. The variety of raw materials that can be produced in Ethiopia has been defined.

For details see Annexure 8

Steps remaining to be taken:

1. The research centre has to develop the required process know how or acquire the same from experts.

2. The required production facilities have to be set up.

For details of equipment required see annexure 8

Related benefits likely to accrue to Ethiopia due to the establishment of the aforementioned facilities:

1. Establishment of a new pioneering industry directly leading to the introduction of new technology.

2. Generation of new employment opportunities in both the industrial as well as the agricultural sectors.

3. Production of import substition items.

4. Creation of market for locally produceable raw materials.

ANNEXURE 8

LIST OF THE VARIETY OF RAW MATERIALS THAT CAN BE PRODUCED IN ETHIOPIA

For Fragrances

1. Citronellal
2. Citronellol
3. Dimethyl Octanol
4. Citronellyl Acetate
5. Citronellyl Butyrate
6. Citronellyl Formate
7. Citronellyl Valerate
8. Geraniol
9. Geranyl Acetate
10. Geranyl Butyrate
11. Geranyl Formate
12. Geranyl Propionate
13. Geranyl Valerate
14. Citral
15. Alfa Ionone
16. Ionone Pure
17. Methyl Ionone
18. Menthol
19. Eugenol
20. Isoeugenol
21. Acetyl Isoeugenol
22. Linalol
23. Linalyl Acetate
24. Hydroxy Citronellal
25. Para Cresyl Acetate
26. Para Cresyl Methyl Ether
27. Para Cresyl Phenyl Acetate
28. Aldehyde C-16
29. Aldehyde C-14
30. Yara Yara
31. Nerolin Bromelia
32. Rose Crystals
33. Alpha Amyl Cinnamic Aldehyde
34. Alpha Hexyl Cinnamic Aldehyde
35. Cinnamic Aldehyde
36. Cinnamic Alcohol
37. Phenyl Propyl Alcohol
38. Benzyl Acetate
39. Benzyl Formate
40. Benzyl Propionate
41. Benzyl Butyrate
42. Benzyl Salicylate
43. Benzyl Benzoate
44. Benzyl Phenyl Acetate
45. Benzaldehyde
46. Phenyl Acetic Acid
47. Amyl Phenyl Acetate
48. Isobutyl.Phenyl Acetate
49. Ethyl Phenyl Acetate
50. Methyl Phenyl Acetate
51. Styrallyl Alcohol

For Flavours

1. Ethyl Acetate
2. Ethyl Formate
3. Ethyl Propionate
4. Ethyl Butyrate
5. Ethyl Valerate
6. Ethyl Caproate
7. Ethyl Heptoate
8. Ethyl Caprylate
9. Ethyl Pelargonate
10. Iso propyl cinnamate
11. Isobutyl Acetate
12. Allyl Caproate
13. Allyl Caprylate
14. Aldehyde C-20
15. Amyl Formate
16. Amyl Acetate
17. Amyl Butyrate
18. Amyl Alcohol
19. Isobutyl valerate
20. Amyl Valerate
21. Ethyl Salicylate
22. EThyl Benzoate
23. Isopropyl Valerate
24. Amyl Propionate

52. Styrallyl Acetate
53. Phenyl Ethyl Alcohol
54. Phenyl Ethyl Acetate
55. Phenyl Ethyl Formate
56. Phenyl Ethyl Isobutyrate
57. Methyl Cinnamate
58. Methyl Salicylate
59. Amyl Salicylate
60. Isobutyl Salicylate
61. Nerol

Since these chemicals from the greater part of any fragrance or flavour compositions, the start up of indigenous manufacture of these chemicals will immediately satisfy more than 50% of the demand for raw materials by the Ethiopian Industry.

EQUIPMENT REQUIRED TO SET UP THE PRODUCTION FACILITY FOR AROMA CHEMICALS

1. Fractionation columns
2. Vacuum pumps... high vacuum + water ring type
3. Reaction vessels
4. Washing vessels
5. Centrifuges
6. Storage tanks
7. Filtration equipment
8. Distillation columns
9. Cooling tower
10. Dryers
11. Water circulation system
12. Steam boiler
13. Thermic fluid heater
14. Chilling plant
15. Stand by electricity generaters
16. Analytical and quality control equipment

ANNEXURE 9

WORLD MARKET DATA

EXPORT POTENTIAL OF ESSENTIAL OILS IN THE CONTEXT OF WORLD TRADE

The total export market for essential oils and perfumery compounds has been estimated as amounting to US$ 1323.5 million and 1514.5 million respectively.

Similarly the total market in terms of imports for the same two years amounted to US$ 1366.9 million and US$ 1522.6 million respectively.

The volume of exports is not detailed. However, ten major exporting countries are responsible for approximately 82.5% of the world's exports as indicated below. (Table 1)

TABLE 1 : EXPORTS OF ESSENTIAL OILS

Country	Value in US$ '000	Percentage of Total Exports Value
France	305,511	20.2
USA-Puerto Rico	227,058	15.0
Switzerland	195,922	12.9
U.K.	162,089	10.7
Netherlands	136,437	9.0
F.R.G.	99,284	6.6
Italy	40,712	2.7
Egypt	13,307	0.9
Brazil	29,096	1.9
Iceland	38,755	2.6
	Total	82.5

TABLE 2

WORLD EXPORTS OF ESSENTIAL OILS, PERFUMES ETC. AND ESSENTIAL OILS AND RESINOIDS

Major Exporting countries	Essential Oils/ Perfumes			Essential Oils/ Resinoids	
	Qty in tonnes	Value $ '000	% of total exports	Qty in tonnes	Value $ '000
France	14309	263238	19.89	58705	133391
United States-Puerto Rico	37196	204613	15.46	25319	101847
Switzerland	7128	181924	13.75	716	12701
United Kingdom	15215	130571	9.87	2101	23405
Netherlands	10884	121892	9.21	596	10923
Germany Fed.Rep.	6716	83187	6.29	709	7923
Egypt	267	27646	2.09	132	19430
Ireland	1924	27435	2.07	37	260
Italy	2114	26320	1.99	876	16980
Hongkong	?	25600	1.93	?	7208
Brazil	12064	24528	1.85	8896	21528
Japan	1790	24300	1.84	100	2849
Spain	1984	15665	1.18	1316	10150
Haiti	?	?	1.12	?	?
India	?	?	1.07	?	?
Indonesia	2271	11945	0.90	2266	11916
Paraguay	?	8497	0.64	---	----
Argentine	776	8393	0.63	728	7769
Singapore	?	7755	0.59	683	6437
Belg./Lux.	1463	7695	0.58	55	1974
Reunion	89	7401	0.56	89	7400
Mexico	---	---	0.49	---	---

			94.01		

(World Exports in US$ '000 = 1323454)

From the break-up, it is evident that France has been the world's leading exporter of both Essential Oils and Perfumes (its contibution being 19.89%) and Essential Oils and Resinoids. France is closely followed by USA-Puerto Rico, Switzerland, United Kingdom, Netherlands, German Federal Republic, Egypt, Ireland, Italy, Hongkong, and Brazil in that order.

As could be observed, the data is respect of the 22 countries make up 94.01 % of the world total exports of Essential Oils and Perfumes. It is interesting to note that the leading exporters of Essential Oils and Perfumes are not necessarily the leading exporters of Essential Oils

and Resinoids. A further break-up in terms of leading exporting countries of Essential Oils and Resinoids is available and is reproduced as Table 3. From this, it could be observed that many of the developing countries like China, Brazil, Egypt, Mexico, Indonesia, Reunion Islands as also India happen to be amongst the exporters of Essential Oils and Resinoids.

Details in respect of the world's leading importing countries of Essential Oils and Perfumes and Essential Oils and Resinoids are presented in Table 4.

TABLE 3

LEADING EXPORTING COUNTRIES IN ESSENTIAL OILS AND RESINOIDS

Country	Qty in tonnes	Value in $ '000
France	5870	133391
USA, Puerto Rico	25319	101847
China	---	27068
UK	2101	23405
Brazil	8896	21528
Egypt	132	19430
Italy	876	16980
Mexico	---	14083
Switzerland	716	12701
Indonesia	2266	11916
Netherlands	596	10923
Spain	1316	10150
India	---	9137
German Fed.Rep.	709	7923
Argentina	726	7769
Reunion	89	7400
Hongkong	---	7208
Singapore	683	6437
Madagascar	1086	6274
Marocco	221	5548
USSR	---	5519
Bulgaria	---	4370
Japan	100	2849
Tunisia	212	2845
Ivory Coast	160	2317
Austria	141	2281
Turkey	5	2214
Canada	166	2126
Belg./Lux.	55	1974
Portugal	431	1615
Greece	290	1286
Denmark	71	813
Israel	1071	786
Ireland	37	260
Sweden	21	126
	54362 tons	492499

TABLE 4

WORLD IMPORTS OF ESSENTIAL OILS, PERFUMES ETC. AND ESSENTIAL OILS AND RESINOIDS IN US $ '000

Major Importing Countries Essential Oils and Perfumes Percent Essential Oils and Resinoids

Country	Qty.in tons	Value $ '000		Qty in tons	Value $ '000
USA - Puerto Rico	12442	173503	12.69	7492	110220
France	9376	132190	9.67	6719	92701
Germany Fed.Rep.	11785	128835	9.43	4606	37483
UK	8130	106625	7.80	5762	65911
Japan	6700	98220	7.19	4379	45799
Venezuela	25597	53076	3.88	---	---
Italy	5041	52235	3.82	2035	12907
Netherlands	5166	44483	3.25	1956	20176
Switzerland	3479	43407	3.18	2074	26497
Spain	4119	42375	3.10	1840	13982
Canada	1885	25065	1.83	961	12131
Korea Rep.	1239	21893	1.60	280	5492
Nigeria	?	?	1.44	?	?
Belgium/Luxemburg	2039	19058	1.39	314	3415
Aurstralia	?	18819	1.38	---	---
South Africa Rep.	?	18252	1.34	?	?
Hong Kong	?	18243	1.33	541	6340
Philippines	1886	16175	1.18	390	6050
Yogoslavia	1233	15637	1.14	156	2059
Thailand	---	14578	1.13	---	2914
			77.78		

(World imports $ '000 - 1366941)

Here it may be observed that the USA -Puerto Rico is the leading importer followed by France, Federal Rep. of Germany, United Kingdom, Japan, etc. in that order. Once again it is evident that leading importers of the category Essential Oils and Perfumes are not necessarily the major importers of the category Essential Oils and Resinoids.

However, world exports as depicted in the International Statistics in respect of Essential Oils and Perfumes do not include exports from the countries with centrally planned economies like China which are amongst the leading exporters of Essential Oils and Resinoids. But from the countrywise import statistics in the "Commodity Trade Statistics" under the group 551.1 with the break-up value in respect of supplying countries, one could have a rough indication of exports effected by countries like China, USSR etc. to each of the countries and adding the sum total of the exports one could get a rough indication of their exports. Similarly, this information could also be computed from the

World Trade Annual which again gives a break-up in respect of sub-group 551.1 for the 24 OECD countries (Organization for Economic and Commercial Development) with details effected by supplying countries. The information pertaining to exports for the given in Table 3 for China, Mexico, USSR, Bulgaria as also India have been computed thus.

It can be deduced that the annual world exports of Essential Oils and Resinoids could be approximately 55,000 tons. In this context, details of the quantum of exports under 551.1 furnished in respect of USA which is of the order of 25319 tons apparently include exports of Pine Oil which forms a predominant share of the exports of Essential Oils from USA.

Hence, the figure of 55,000 tons could be assumed to represent the approximate total world exports. Exports in terms of value for the 35 countries given in Table 3 works out to approx. $ 492.5 million and hence, $ 500 million to $ 525 million could be computed as world exports of Essential Oils and Resinoids as the figure of $ 492.5 million does not include exports from countries like Sri Lanka, Guatemala, etc.

The European Economic Community include some of most industrialised countries of the world and import and export statistics in respect of individual essential oils for this group of countries along with the imports and exports of Essential Oils and Resinoids for the individual countries is reproduced in Table 5 and 6. The total exports of Essential Oils and Resinoids by the E.E.C. group of countries have been of the order of 10,300 tons but their imports have been more than double at 22,100 tons. From the details of import and export statistics of the individual essential oils given in Table 5 some assessment of their export possibilities could be made.

TABLE 5

TRADE STATISTICS FOR THE MEMBERS OF EEC (EUROPEAN ECONOMIC COMMUNITY CONSISTING OF WEST GERMANY, FRANCE, ITALY, NETHERLANDS, BELGIUM, UNITED KINGDOM, IRELAND AND DENMARK)

Qty in Tonnes Imports	Description	Qty in Tonnes Exports
4795	Essence of Orange	1147
1360	Essence of Lemon	860
173	Bergamot Oil	160
955	Other Citrus Oil	438
193	Geranium Oil	200
919	Clove,Ylang-Ylang etc.	346
1735	Peppermint Oil	602
151	Vetiver Oil	54
778	Citronella Oil	268
1050	Eucalyptus Oil	190
42	Jasmine Oil	8
645	Lavender oil,Lavendin etc.	1258
15	Essence of Rose	5
146	Coniferous Oils	76
5943	Other Essential Oils	3244
161	Terpenefree citrous oils	57
172	Other Terpenefree Essential Oils	158

356	Resinoids	524
33	Essential Oil Concentrates	46
2504	Terpene Residues	697
22126		10338

TABLE 6

COUNTRYWISE EXPORTS AND IMPORTS OF ESSENTIAL OILS AND RESINOIDS MEMBERS OF THE E.E.C.

Value $ '000	Qty in Tons	Country	Qty in Tons	Value $ '000
37483	4606	German Fed.Rep.	709	7923
92701	6719	France	5870	133391
12907	2035	Italy	876	16980
20176	1956	Netherlands	596	10923
3415	314	Belgium/Luxemb.	55	1974
65911	5762	United Kingdom	2101	23405
5670	333	Ireland	37	260
2585	339	Denmark	71	813
240848	22064		10315	195669

An attempt has also been made Table 7 to arrive at some idea of the exports of certain individual essential oils in terms of world trade. These are approximate estimates only and should only be regarded as such. However they are useful indications for trade consideration.

TABLE 7

ESTIMATED WORLD EXPORT OF INDIVIDUAL ESSENTIAL OILS

1. Orange Oil	10 to 12000 tons	(Brazil 4000 tons to 5500 tons USA - 4000 to 4200 tons Israel - 400 tons Italy, Spain, Marocco)
2. Citronella Oil	4000 to 5000 tons	(Indonesia - 1000 to 1750 tons China - 2000 tons Argentina 200 tons Brazil 30 to 70 tons Guatemala 200 to 250 tons Sri Lanka 120 to 200 tons Taiwan 400 tons)
3. Mint Oil	Approx. 4000 tons	(Mentha Arvensis Brazil 1000 to 1750 tons Paraguay, China, Taiwan) Mentha Piperita - USA 1250 tons Sparmint Oil - USA 600 tons)

4. Eucalyptus Oil	2500 tons	(China 1400 to 1500 tons Portugal 330 to 400 tons Spain - 220 tons Brazil - 170 tons)
5. Lemon Oil	1500 tons to 2000 tons	(Italy - 500 tons USA - 600 tons, Brazil -100 Ivory Coast 120 to 200 tons Greece - 100 tons)
6. Clove Oil (leaf, bud and stem)	1500 to 2000 tons	(Madagascar - 1000 tons Indonesia - 450 to 675 tons Zanzibar - 200 tons)
7. Sassafras Oil	1800 tons	(Brazil 1000 - 1800 tons)
8. Lavender, Lavendin and Spike Lavender	1500 tons	(France - 800 to 1000 Spain - 100 tons Bulgaria - 50 to 80 tons Yugoslavia - 60 tons USSR 30 to 40 tons)
9. Camphor Oil	1500 tons	(Taiwan - 1400 tons)
10. Lime Oil	800 tons	(Mexico - 330 to 570 tons Haiti - 100 tons South America and West Indies - 100 tons)
11. Patchouli Oil	400 to 500 tons	(Indonesia - 540 tons)
12. Cedarwood Oil	500 tons	(USA - 500 tons)
13. Lemongrass Oil	400 - 500 tons	(Guatemala - 175 to 225 tons India - 100 - 200 tons)
14. Rosemary Oil	350 to 450 tons	(Marocco - 50 to 114 tons Spain 100 to 175 tons Tunisia - 135 to 145 tons)
15. Bergamot Oil	300 to 400 tons	(Italy - 80 - 100 tons Brazil, Ivory Coast 20 to 50 tons)
16. Petitgrain Oil	300 to 400 tons	(Paraguay - 200 -300 tons
17. Vetiver Oil	300 tons	(Haiti - 100 -150 tons Indonesia - 100 tons Reunion - 25 tons, Brazil and China - 25 tons)
18. Geranium Oil	250 to 300 tons	(Reunion - 130 tons Egypt - 50 to 100 tons Marocco - 10 -15 tons China - 10-15 tons, Algeria - 10 tons)

19.Eucalyptus Citriodora	200 tons	(Brazil 200)
20.Guaiwood Oil	100 to 150 tons	(Paraguay and Argentine 100 tons)
21.Rosewood Oil (tulip)	100 to 150 tons	(Brazil 100 - 150 tons)
22.Mandarin Oil	100 to 150 tons	(Italy - 50, Argentina, Brazil - 100 tons)
23.Ylang Ylang Oil	100 to 120 tons	(Comores and Madagascar)
24.Cinnamonleaf Oil	100 tons	(Sri Lanka - 100 tons, Seychelles)
25.Cinnamon Bark Oil	0.5 - 1 ton	(Sri Lanka)
26.Amyris Oil	70 tons	(Haiti - 70 tons)
27.Canaga Oil	40 to 50 tons	(Indonesia 50)
28.Jasmine Oil/Concrete	15 - 20 tons	(Egypt 8 to 10 tons Marocco - 2 tons, France 0.5 to 1 ton, Italy 2 to 4 tons, Turkey - 1 ton, South Africa - 0.5 to 1 ton)
29.Rose Oil/Concrete	10 - 15 tons	(Marocco - 3 tons, USSR 2 tons (to EEC), Turkey 2.6 tons, Bulgaria, France - 7 tons (to EEC)

WORLD MARKET DATA

STATISTICS: PRODUCTION OF MAJOR ESSENTIAL OILS IN DEVELOPING COUNTRIES

Name of Oil	Name of the Country	Annual Production in tonnes
Lemongrass (Cymbopogon Flexuosus)	India	800
	Sri Lanka	5
Palmarosa (C.martinii)	India	60
Citronella (C.winterianus)	India (Java type)	350 -400
	Indonesia (Java type)	1300
	Sri Lanka (Ceylone type)	150
Eucalyptus Citriodora Oil (Eucalyptus Citriodora)	India	25
Eucalyptus Globulus Oil (E. globulus)	India	50

Jasmine Concrete (Jasminum grandiflorum)	Egypt	6.5-8.3
Japanese Mint (Mentha arvensis)	India	1500
Bergamot mint (M.citrata)	India	20
Peppermint (M.piperita)	India	30
Geranium (Pelargonium graveolens)	India Egypt	10 50
Patchouli (Pogostemon patchouli)	Indonesia	500
Rose Concrete (Rose gallica)	Egypt	0.35 -0.45
Sandalwood (Santalum album)	India	50 - 60
Vetiver (Vetiveria zizaniolides)	India Indonesia	10 85

STATISTICS: PRODUCTION OF MINOR ESSENTIAL OILS IN THE DEVELOPING COUNTRIES

1	2	3	4
1. Apium graveolens	Celery seed	India	1
2. Artemisia pallens	Davana	India	1
3. A. vestita	Artenisia Vestita	India	Scall quantities
4. Bursera delpechana	Linaloe	India	50
5. Cananna odoratum	Cananga	Indonesia	45
6. Cedrus deodara	Cedarwood	India	15
7. Cinnamomum zelanicum	Cinnamon Leaf	India Sri Lanka	5 110
8. Cumimum cyminum	Cumin	Egypt	0.50 -0.80
9. Eugenia caryophyllata	Clove Leaf	Indonesia	1400
10.Myristica fragrans	Nutmeg	Indonesia Sri Lanka	10 10
11.Piper nigrum	Pepper Oil	Sri Lanka	5

ANNEXURE 10

EXPORT MARKET ASSESSMENT

FOR SELECTED ESSENTIAL OILS WITH POTENTIAL FOR DEVELOPMENT IN ETHIOPIA

1. Geranium Oil : China is currently the world's major producer. The current SPOT price of this product in the London market is $ 33.50 per kilo. The price has risen to this level in one year from a low of $ 25.50 just one year ago.

The current position is that the standard chinese quality called 'Yunnan' is totally sold out. Against this season's supplies and against the material to be obtained from the new crop, the producers are offering only very small quantities at high price levels due to uncertainty about the production. Prices are expected to advance further due to a smaller than usual crop.

2. Palma Rosa Oil : India and Brazil are the world's two major producers. Due to high domestic demand in India not much material is offered on the world market. The current price in the Indian market is $ 18.00 per kilo. The current price in Brazil is $. 24.00 per kilo and small quantities are regularly available.

3. Coriander Oil : Russia is the world's major supplier and the current price is $. 70.00 per kilo. The price has risen to this level in a matter of two years from a low of $ 45.00 per kilo. While supplies continue to be available at present the future is uncertain due to the disturbed conditions prevailing in Russia. Good quality material is especially difficult to find.

4. Spearmint Oil : The current London SPOT market prices are as under:-

Spearmint chinese 60% carvone : $ 16.00 per kilo
Spearmint chinese 80% carvone : $ 23.00 per kilo

Stocks in China are high and demand slow. Prices have declined significantly and could reduce further before a trading level is reached due to sufficient stocks in the hands of many merchants albeit at high prices.

5. Sage Oil : The current London SPOT market prices are as under:-

Sage Oil officinalis 40/50% : $ 50.00 per kilo
Sage Oil officinalis 30% : $ 42.00 per kilo

The current market situation is that practically no new oil is comming out of Yugoslavia and Albania and although for the time being oil in the hands of resellers is adequate it is expected that prices will climb as dealers sell their stocks. The disruption in supplies and the difficult transportation problems certainly will cause a gap in availability.

6. Lemongrass Oil, Guatemalan : For the first time in many years Guatemala completely sold out its production this year. Hence there is nothing available until the new crop commencing June/July. Prices are expected to be a little higher. The current prices are as under:-

Lemongrass oil Cochin : $ 13.25 per kilo Spot London
Lemongrass oil Guatemalan : $ 9.25 per kilo Spot London
(minimum Citral 75%)

7. Eucalyptus Citriodora : The current market price for Chinese material is US $ 4.80 per kilo Spot London.
During the recent Canton Fair, shippers in China tried to push selling levels upwards. However the customers did not show a great deal of interest, and as such the prices did not rise. The price level is not expected to rise in the near future.

ANNEXURE 11

DETERMINATION OF PLANT CAPACITY AND THE PRODUCT MIX

Plant Capacity : The existing unit at Wendo Guenet for the production of essential oils consists of two steam distillation stills -- one of 300 litre charge capacity and one of 500 litre charge capacity. If the cultivation of essential oil bearing crops is to be confirmed to the existing site at Wendo Guenet consisting of about 100 hect. of farm land, then the two existing units are adequate to take care of the production.

There is, further, another distillation still of similar capacity available on the site--- the mobile distillation unit. This still has not been commissioned to date and has been lying unused since it was received from India. The basic design of the still is quite correct but as in any new equipment there were apparently some teething troubles in commissioning the said unit and due to these it was abondoned. In the opinion of this expert this still should be commissioned either as a Mobile Unit as per the original design or with slight modifications it should be commissioned as a stationery unit.

THE REASON FOR THIS SUGGESTION IS THAT IF CULTIVATION OF THE ESSENTIAL OIL BEARING CROPS EXPANDS BEYOND THE 100 HECTARES OF THE WENDO GUENET STATION, THEN THE EXISTING TWO UNITS WILL BECOME INADEQUATE. UNDER THE PRESENT ECONOMIC CONDITIONS IT IS DIFFICULT TO ENVISAGE THAT OUTGROWERS WILL OR CAN BE PROVIDED WITH THEIR OWN STILLS. UNDER SUCH CIRCUMSTANCES THE ADDITIONAL CAPACITY REPRESENTED BY THE MOBILE UNIT WILL BECOME OF CRITICAL IMPORTANCE SINCE IT WILL BE ABLE TO MOVE FROM ONE SITE TO ANOTHER IN THE REGION AND DISTILL THE OIL IN FRONT OF THE FARMER ON HIS FIELD. THIS DEMONSTRATION OF TECHNOLOGY WILL SERVE TO EARN THE CONFIDENCE OF THE FARMERS AND HELP IN EXTENDING THE CULTIVATION AND DISTILLATION PRACTICES AMONG THE RURAL MASSES WHO ARE SUPPOSED TO BE THE MAIN BENEFICIARIES OF THIS PROJECT.

Further enhancement of capacity beyond these existing units is not feasible at the moment due to uncertainty regarding the extent of the cultivation that will ultimately be undertaken by the project authorities.

Product Mix : As has already been suggested elsewhere in this report the following essential oil bearing crops should be taken up for cultivation on a priority basis :-

Geranium
Palma Rosa
Coriander
Mentha Spicata
Sage
Rosemary
Basil, Indian
Eucalyptus Citriodora
Mentha Piperita
Thyme

This selection of crops and the consequent product mix has been made on the following consideration:=

1. Availability of planting material with the NCC

2. Suitability of the planting material to the eco-climatic conditions prevailing at Wendo Guenet.

3. Potential of bulk sales in the world market on the basis of currently prevailing situation.

4. High unit value realisation for the resultant essential oils

5. Possibility of utilising these essential oils to produce Isolates, Derivatives and Frangrance and Flavour compounds in Ethiopia to substitute a part of the imports by local production.

6. Possibility of utilising items like coriander, spearmint, sage, rosemary and thyme as herbs and spices in the domestic as well as the export markets.

Production Schedule and Capacity:

Based on the requirements of the world market, it is suggested that sufficient areas should be planted so to yield the following quantities of these oils:-

Geranium Oil	5000 kilos
Palma Rosa Oil	3000 kilos
Coriander Oil	2000 kilos
Spearmint Oil	1000 kilos
Sage Oil	1000 kilos
Rosemary Oil	1000 kilos
Basil, Indian	1000 kilos
Eucalyptus Citriodora Oil	7000 kilos
Mentha Piperita Oil	1000 kilos
Thyme Oil	1000 kilos

Since it will not be feasible or practical to plant the entire amount of the requisite areas simultaneously, it is suggested that the planting be carried out in the order mentioned above and consequently the production of essential oils will also be obtained to the same extent and in the same order.

ANNEXURE 12

IMPORTANT TRADING HOUSES IN MAJOR MARKET CENTRES

Name & Full Address.	Telephone No.	Telex No.
1. M/s. John Kellys (London) Ltd., Prescot House, Prescot Street, London E1 8BB (Dealers)	71-48212110 (10 Lines)	884659 & 884650
2. M/s. Furest Day Lawson Ltd., St. Clare House, 30-33 Minories London EC3N 1LN (U.K.) (Dealers)	01-4880777	887871 & 8952097
3. M/s. R.C. Treatt & Co. Ltd., Northern Way, Bury St. Edmunds, Suffolk, England 1P32 6NL. (Dealers)	0284-702500	81583
4. M/s. Albert Vieille, Subreville, B.P. 40, Route De Grasse 06220 Vallauris (France)	637405 & 637430	470875
5. M/s. Agipal, 12, Rue De Puebla, B.P. No.50, 78600 Maisons-Laffitte (France)	(1)39623277	698198
6. M/s. H. Reynaud & Fils, 26570 Montbrun-Les-Bains France.	75280255	345690
7. M/s. Southseas Essential Oils Co. No.36A, Hillview Terrace, Singapore - 2366.	7641070 & 7641071	42049
8. M/s. Flavodor B.V., Industrieweg 78, 5145 PW Waalwijk, Holland (Netherlands) (Dealers)	04160-40405	35435
9. M/s. Adrian S.A., 15, Rue De Cassis, 13008 Marseille B.P. 89/13268 Marseille Cedex 8. (France) (Dealers)	91.79.91.81	410085
10. M/s. Citrus & Allied Essences Ltd. 65, South Tyson Avenue, Floral Park, N.Y.11001 (USA).	212-343-0030 516 354-1200	967736 6852146

11.M/s. Firmenich Inc. — Processors/Compounders
Case Postale 239,
CH-1211 Geneva -8
Switzerland

12.M/s. Felton International Inc. — Flavour House
599 Johnson Avenue
Brooklyn N Y 11237

13.Fritzsche Dodge and Olcott Inc. — Processors/Manufacturers
76 Ninth Avenue
New York
NY 10011

14.Givaudan Roure S.A. — Processors/Compounders
1214 Verneir
Geneve. (Switzerland)

15.Haarmann & Reimer GmbH — Processors/Compounders
D-3450 Holzminden
West Germany

16.M/s. D.W. Hutchinson and Co. — Dealer
700 South Columbus Avenue
Mount Vemom
NY 10550

17.International Flavours & Fragrances — Processors/Compounders
I.F.F. (Nederland) B.V.
Liebergerweg, 72-98, Hilversum
Holland.

18.Ivolin Enterprises — Dealer
500 Fifth Avenue
Suite 4330, New York
NY 10036.

19.M/s. Kalsec Inc. — Flavour House
P.O. Box 511
Kalamazoo
MI 49005

20.M/s. Lautier Aromatiques — Processors/Importers
5 Peri Court
Allendale
NJ 07401

21.M/s. Lever Brothers Co. — End-Users
390 Park Avenue
New York
NY 10022

22.M/s. Ludwig Mueller Co. Inc. — Brokers
2 Park Avenue
New York
NY 10016

23.M/s. J. Manheimer Inc. — Dealer
47-22 Pearson Place
Long Island City
NY 11101

24.M/s. Naarden International USA Inc. 43-23 37th Avenue Long Island City NY 11101	Processors/Compounders
25.M/s.Norda Inc. 140 Route 10 East Hanover NY 07936	Processors/Compounders
26.M/s. Polak's Frutal Works Inc. Middletown NY 10940	Processors/Compounders
27.M/s. Polarome International Inc. 22 Ericsson Place, New York.	Dealer
28.M/s. SCM Organic Chemicals Clark Road PO Box 389 Jacksonville FL 32201	Manufacturers of Synthetic Perfumery and Flavouring materials
29.M/s. E.L. Scott and Co.Inc. 1 World Trade Centre Suite 2347 NY 10048	Agents
30.M/s. George Uhe Co. Inc. 76 Ninth Avenue New York NY 10011	Broker
31.M/s. Ungerer and Company 4 Bridgewater Lane PO Box U Lincoln Park NJ 07035.	Processors/Manufacturers
32.M/s. Union Camp Corporation, PO Box 60369 Jacksonville FL 32205	Manufacturers of Aromatic Products
33.M/s. Quest International Ashford, Kent TN24 0LT England.	Processors/Compounders
34.M/s. R. Sarant and Co. Ltd., Priestley Road, Basingstoke Hants RG24 9PU.	Dealers/Compounders
35.M/s. A.E. Wells and Co. (Produce) Ltd., 500 Old Kent Road, London SE1 5AH	Dealers

36.M/s. Zimmermann Hobbs Ltd., Dawson Road, Bletchley Milton Keynes Bucks MK1 1JR	Compounders
37.M/s. Benard et Honnorat SA BP 67 06332 Grasse.	Processors/Compounders
38.M/s. Madame Boyer 62 Rue Lafayette 75009 Paris	Brokers
39.M/s. Pierre Chauvet SA 83770 Seillans.	Essence Manufacturers
40.M/s. Les Fils et Petits-Fils De Maurice Duclos 8 Place Vendome 75001 Paris	Brokers
41.M/s. Lautier Fils 06 Grasse.	Processors/Compounders
42.M/s. V. Mane Fils, 06620 Bar-Sur-Loup France.	Processors/Compounders
43.M/s. P. Robertet et Co., Avenue Sidi-Brahim 06333 Grasse.	Processors/Compounders
44.M/s. Schmoller et Bompard Chemin De La Madeleine 06331 Grasse	Processors/Compounders
45.M/s. Cornehls and Bosse Bei Den Mohren 91 2000 Hamburg 11. Germany.	Broker
46.M/s. Dragoco GmbH D-3450 Holzminden. Germany.	Processors/Compounders
47.M/s. Hermann Dullberg Alsterdorfertrasse 19 D-2000 Hamburg.	Essential Oil Manufacturers
48.M/s. Frey and Lau Behringstrasse 116 D-2000 Hamburg 50.	Essential Oil Manufacturers
49.M/s. Paul Kaders GmbH Eschelsweg-27, P.O.B 500826, D-2000 Hamburg 50.	Dealers
50.M/s. C.Melchers and Co., 48A Steindamm D-2820 Bremen 77.	Dealers

51.M/s. Worlee-Drogen Bellevue 7-8 2000 Hamburg 60.	Dealers
52.M/s. Maschmeijer Aromatics PO Box 4170 Ornval 81 1009 AD Amsterdam	Processors/Compounders
53.M/s. Mirandolle, Voute and Co BV Maasstraat 12A-14A, 3016 DC Rotterdam.	Dealers/Agents
54.M/s. Polak's Frutal Works Nijverheidsweg Zuid 7 Amersfoort.	Processors/Compounders
55.M/s. A. Valenkamp BV Prins Hendrikkade 152 1011 AW Amsterdam.	Broker
56.M/s. Jules Chiquet SA Dreispitzstrasse 11 Bau 181 4142 Basle. (Switzerland)	Dealers
57.M/s. Puressence Zorich Blumlisalpstrasse 3 8033 Zorich. (Switzerland)	Dealers
58.M/s. Bush Boake Allen Ltd., Blackhorse Lane, London E17 5QP.	Processors/Compounders
59.M/s. Dragoco (GB) Ltd., Lady Lane Industrial Estate, Hadleigh, Ipswich, Suffolk IP7 6AX (U.K.)	Processors/Dealers
60.M/s. T.M. Duche and Sons (UK) Ltd Berisford House 50 Mark Lane London EC3R 7QS.	Dealers/Merchants
61.M/s. S. Figgis and Co. Ltd., 53, Aldgate High Street, London EC3N 1LU.	Brokers
62.M/s. Lionel Hitchen (Essential Oils) Ltd., 50 Albert Road North Reigate, Surrey. (U.K.)	Processors/Compounders
63.M/s. International Flavours and Fragrances (GB) Ltd., Crown Road, Southbury Road, Enfield, Middlessex EN1 1TX. (U.K.)	Processors/Compounders
64.M/s. Pauls and Whites International Albert Road North Reigate Surrey. (U.K.)	Manufacturers of Flavouring Essences

ANNEXURE 13

RECOMMENDATIONS REGARDING THE MOST FEASIBLE TYPES AND QUALITIES OF ESSENTIAL OILS THAT CAN BE MARKETED

On the basis of demand in the world market it has been assessed that there is a gap in the supply of certain essential oils. These shortages or gaps in the supply position occur due to many reasons, some of which are as follows:-

1. Change in climatic conditions

2. Competition from other alternate crops

3. Political instability

4. Lack of suitable planning

5. Indadequate availability of labour during crucial periods

6. Cyclical nature of the commodities trade in as much as it applies to the essential oils business

With regard to the development of the essential oils industry in Ethiopia, the eco-climatic conditions prevailing in the country as well as the planting material available have been taken into consideration in determining the types of essential oil bearing crops that should be cultivated here. From the marketing point of view also, the gaps in the supply position in the world market have been considered.

It is recommended that the following essential oil bearing crops should be taken up for cultivation:-

Geranium
Palma Rosa
Coriander
Spearmint
Sage
Rosemary
Basil, Indian
Eucalyptus Citriodora
Mentha Piperita
Thyme

The corresponding essential oils that will be produced from these crops have to be subjected to vigourous and accurate quality control to bring them in line with the internationa ly traded qualities so as to fetch the ruling market price at any time.

The qualities of internationally traded essential oils are assessed in accordance with certain internationally accepted and recognised standards.

The standards used internationally are primarily issued by the following organisations:-

1. International Organisation for Standardisation, Geneva

2. British Standards Institution, London

3. Essential Association of the USA, New York.

In addition a lot of countries like India have their own national standards which are used to control the qualities of the essential oils being exported from the country.

The factors involved in quality assessment and standard specifications for the oils of Lemongrass, Citronella and Eucalyptus are detailed hereunder.

In general, it may be said that compliance with international standards and specifications is necessary requirement of any marketing effort to undertaken by any developing country. Thus the following oils which are recommended to be produced by Ethiopia should in general be in accordance with the standards issued by the aforementioned organisations. In addition for the sake of establishing credibility in the world market, it would be advisable to evolve national standards for the oils being produced in Ethiopia. This will also serve to control the qualities of oils consumed domestically.

QUALITY ASSESSMENT AND STANDARD SPECIFICATIONS FOR THE OILS OF LEMONGRASS, CITRONELLA AND EUCALYPTUS

THE QUALITY OF AN ESSENTIAL OIL MAY BE ASSESSED BY A BUYER ON THE BASIS OF A NUMBER OF CRITERIA: THE ODOUR AND/OR FLAVOUR CHARACTER, THE CHEMICAL COMPOSITION AND CERTAIN PHYSICAL PROPERTIES, FREEDOM FROM ADULTERATION, AND GENERAL CLEANLINESS AND APPEARANCE. THE RELATIVE IMPORTANCE OF EACH OF THESE CRITERIA WILL DEPEND UPON THE INDIVIDUAL ESSENTIAL OIL AND ITS INTENDED END-USE. FOR EXAMPLE, IF THE OIL IS TO BE EMPLOYED PER SE FOR PERFUMERY OF FLAVOURING APPLICATIONS, THE ACCEPTABILITY OF THE ODOUR OR FLAVOUR CHARACTER ARE OF PRIMARY IMPORTANCE TO THE BUYER AND THESE PROPERTIES ARE ASSESSED BY SUBJECTIVE MEANS; WHEREAS AN OIL WHICH IS TO BE SUBJECTED, BY THEBUYER, TO FURTHER PROCESSING (FRACTIONATION) TO OBTAIN ISOLATES WILL BE PRINCIPALLY EVALUATED ON THE RELATIVE ABUNDANCE OF THE DESIRABLE CHEMICAL COMPONENTS.

The following notes highlight the important quality assessment criteria for each of the oils covered in this report.

STANDARD SPECIFICATIONS FOR THESE OILS HAVE BEEN PUBLISHED BY A NUMBER OF ORGANISATIONS, MAINLY NATIONAL STANDARDS BODIES OR TRADE ASSOCIATIONS IN THE MAJOR CONSUMING COUNTRIES. THE FOLLOWING NOTES INCLUDE, WHERE APPLICABLE, SUMMARIES OF THE MAIN POINTS OF THE STANDARD SPECIFICATIONS PUBLISHED BY THE INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO), THE BRITISH STANDARDS INSTITUTION (BSI) AND THE ESSENTIAL OIL ASSOCIATION OF THE USA (EOA); THE LAST NAMED ORGANISATION HAS NOW BEEN SUBSUMED BY THE FRAGRANCE MANUFACTURERS ASSOCIATION (FMA) TO THE USA, WHICH IS NOW RESPONSIBLE FOR ISSUING AND REVISING THE STANDARDS. THE ADDRESSES OF

THESE THREE BODIES FROM WHICH THE COMPLETE STANDARDS MAY BE OBTAINED ARE LISTED AT THE END OF THE FOURTH PARAGRAPH.

THE PUBLISHED STANDARD SPECIFICATIONS INCLUDE A DEFINITION OF THE ACCEPTABLE BOTANICAL SOURCE AND PROCESSING METHOD FOR THE PARTICULAR OIL, A DESCRIPTION OF THE COLOUR AND ODOUR, SPECIFICATIONS FOR CERTAIN PHYSICO-CHEMICAL PROPERTIES AND THE ANALYTICAL PROCEDURES TO BE USED. ALL EXPORTERS SHOULD ENSURE THAT THEIR PRODUCTS CONFORM TO THE REQUIREMENTS OF THE ISO STANDARD SPECIFICATIONS OR, WHERE APPROPRIATE, THOSE OF THE NATIONAL STANDARDS BODY OF THE PARTICULAR IMPORTING COUNTRY. HOWEVER, IT MUST BE APPRECIATED BY EXPORTERS THAT THE STANDARD SPECIFICATIONS ARE PRINCIPALLY OF GUIDANCE VALUE, DEFINING THE MINIMUM REQUIREMENTS OF BUYERS; SOME BUYERS HAVE MORE STRINGENT 'IN-HOUSE' QUALITY CRITERIA AND THE STANDARD SPECIFICATIONS CANNOT ADEQUATELY DEFINE THOSE PROPERTIES WHICH INVOLVE A BUYER'S SUBJECTIVE JUDGEMENT, SPECIFICALLY THE ODOUR AND FLAVOUR CHARACTER.

Addresses:

International Organization for Standardization, PO Box 56, CH-1211 Geneva 20, Switzerland

British Standards Institution, British Standards House, 2 Park Street, London W1A 2BS

Essential Oil Association of the USA Inc., 60 East 42nd Street, New York, NY 10017, USA

Oils of Lemongrass

'West Indian' and 'East Indian' lemongrass oils possess somewhat different, properties, but are assessed for quality on similar criteria. The main quality criteria are the odour character, the aldehyde (citral) content and the solubility in 70% alcohol. Most commercial oils contain between 75% and 90% aldehydes, and a high value is desired if the oil is intended for fractionation and the isolation of citral. Oils of a high solubility and a good aroma are preferred for direct pefumery applications. Other factors of significance in quality assessment are the appearance and cleanliness.

Oil of West Indian Lemongrass:

The standard specifications of the ISO (ISO 3217-1974), the BSI (BS2999/35:1971) and the EOA (EOA No. 7:1963) define this oil as the product of steam distillation of the grass of Cymbopogon citratus Stapf. The main requirements of these standards are:

	ISO 3217-1974	BS2999/35:1971	EOA No.7:1963
Relative density at 20/20°C:	0.872 to 0.897	----	----
Apparent density at 20°C, g ml :	-----	0.870 - 0.895	----
Specific gravity at 25/25°C:	-----	----	0.869 - 0.894
Refractive Index at 20°C:	1.4830 -1.4890	1.4830 -1.4890	1.4830 -1.4890

Optical rotation at 20°C:	-3° to +1°	-3° to +1°	-3° to +1°
Total aldehydes (carbonyls), expressed as citral:	75%, minimum	75%, minimum (denoted in the standard as a minimum carbonyl value of 276)	75%, minimum
Solubility in 70% (v/v) ethanol:	Freshly distilled oil soluble at 20°C	----	Soluble with cloudiness at 25°C

Oil of East Indian lemongrass:

The standard specifications of the BSI (BS2999/35: 1971) and the EOA (EOA No.7:1963) define this oil as the product of steam distillation of the grass of Cymbopogon flexuosus Stapf. The main requirements of these standards are:

	BS2999/35:1971	EOA No.7:1963
Apparent density at 20°C, g ml	0.893 to 0.903	----
Specific gravity at 25/25°C:	----	0.894 to 0.904
Refractive Index:	1.4830 - 1.4890 at 20°C	1.4830 - 1.4890 at 25°C
Optical rotation at 20°C:	-3° to +1°	-3° to +1°
Solubility in 70% (v/v) ethanol:	1 volume in 3 volumes at 20°C	1 volume in 2-3 volumes at 25°C
Total aldehydes (carbonyls), expressed as citral:	72%, minimum (denoted in the standard as a minimum carbonyl value of 265)	75%, minimum

Oils of Citronella

The principal quality assessment criteria for both Java-type and Ceylon-type citronella oil are the odour character and the chemical composition. In the case of Java-type citronella oil, particularly when purchased for fractionation purposes, the minimum requirement for chemical composition specified in a contract is often 85% total alcohols (expressed as geraniol) and 35% total aldehydes (expressed as citronellal).

Oil of Citronella, Java-type:

The standard specifications of the ISO (ISO 3848-1976), the BSI (BS2999/19:1972) and the EOA (EOA No.14) define this oil as the product of steam distillation of the leaves of Cymbopogon winterianus Jowitt. The main requirements of these standards are:

	ISO 3848-1976	BS2999/19:1972	EOA No.14
Relative density at 20/20°C:	0.880 - 0.895	----	----
Apparent density at 20°C, g ml	----	0.880 -0.892	----
Specific gravity at 15/15°C:	----	----	0.883 -0.900

Refractive Index at 20°C:	1.4660 -1.4730	1.4660-1.4730	1.4660-1.4750
Optical rotation at 20°C:	-5° to 0°	-5° to 0°	-6° to -0° 30'
Solubility in 80% (v/v) ethanol at 20°C:	1 volume in 2 volumes	1 volume in 2 volumes	1 volume in 1-2 volumes
Total alcohols, expressed as geraniol:	85%,minimum (denoted in standard as ester value after acetylation of 250, minimum)	85%,minimum (denoted in standard as ester value after acetylation of 250, minimum)	85% to 97%
Total aldehydes, expressed as citronellal:	35%,minimum (denoted in standard as carbonyl value of 127,minimum)	35%,minimum (denoted in standard as carbonyl value of 127,minimum)	30% to 45%

Oil of citronella, Ceylon-type:

The standard specifications of the BSI (BS2999/18:1972) and the EOA (EOA No.12) define this oil as the product of steam distillation of the leaves of Cymbopogon nardus (L) Rendle var. nardus. The main requirements of these standards are:

	BS2999/18:1972	EOA No.12
Apparent density at 20°C, g ml	0.893 to 0.910	----
Specific gravity at 15°C:	----	0.898 to 0.910
Refractive Index at 20°C:	1.4790 to 1.4850	1.4790 to 1.4850
Optical rotation at 20°C:	-18° to -9°	-18° to -9°
Solubility in 80% (v/v) ethanol at 20°C:	1 volumes in 2 volumes	1 volumes in 1-2 volumes
Total alcohols, expressed as geraniol:	59% to 65% (denoted in standard as ester value after acetylation of 185 to 201)	55% to 65%
Total aldehydes, expressed as citronellal:	7% to 15% (denoted in standard as carbonyl value of 25 to 55)	7% to 15%

Oil of Eucalyptus Citriodora

Oil of Eucalyptus citriodora is primarily assessed on its odour character and its total aldehyde content (expressed as citronellal); the latter is of principal importance when the oil is to be used as a source of citronellal.

Standard specifications have been published by the ISO (ISO 3044-1974), the BSI (BS2999/23:1972) and the EOA (EOA No.130) and these define the oil as the product of steam distillation of the leaves (and terminal branchlets) of E. Citriodora Hook. The main requirements of these standards are:

	ISO 3044-1974	BS2999/23:1972	EOA No.130
Relative density at 20/20°C:	0.858 -0.877	----	-----
Apparent density at 20°C, g ml	----	0.856 -0.875	-----
Specific gravity at 25/25°C:	----	----	0.860 -0.875
Refractive Index at 20°C:	1.4500 -1.4590	1.4500 -1.4590	1.4510 -1.4640
Optical rotation at 20°C:	-2° to +4°	-2° to +4°	-0.5° to +2°
Solubility in ethanol at 20°C:	1 volume in 2 volumes of 80% (v/v)ethanol	1 volume in 2 volumes of 80% (v/v)ethanol	1 volume in 3 volumes of 70%
Total aldehydes, expressed as citronellal:	70% (m/m), minimum	70%, minimum (denoted in standard as carbonyl value of 255, minimum)	65% to 85%

ANNEXURE 14

DESCRIPTION OF DIFFERENT MARKETING ARRANGEMENTS COMMON FOR THE ESSENTIAL OIL TRADE

The cultivation of essential oil bearing crops and the production of the relevant oils is primarily confirmed to the developing countries whereas, as will be seen from the statistics given elsewhere in the report, the markets lie primarily in the developed countries.

Due to the general lack of sophistication in the Industrial and Business practices followed in the developing countries, regulation of the trade so as to ensure a regular uninterupted supply at steady rates becomes a major concern of the international market. In order to achieve these objectives, certain practices are regularly followed in the international market place which concern themselves with the various aspects of the production, sale and distribution of essential oils.

To understand these practices, the same may be studied in the following sequential manner:-

1. The trade, industry and the scientific institutions in a developing country screen the flora and identify potential sources of essential oils.

Simultaneously the eco-climatic conditions of the country are studied and on the basis of similar conditions prevailing else where in the world,crops not normally growing in the country but with a potential for cultivation are identified.

In order to be ultimately able to market the essential oils produced from these crops, both the efforts is screening of flora and eco-climatic conditions are carried out in collaboration with major international buyers and the domestic consuming industry if it exists.

This ensures that as a result of the screening process, only those crops are taken up for cultivation for which a definite market exists either internationally or domestically.

2. After the selection of the crop, it is planted on trial plots and detailed agronomic studies are carried out to establish the feasibility of cultivation and the cost of production.

This step is also carried out in collaboration or co-operation with international buyers or the domestic industry so as to ensure that the correct quality of the requisite essential oil is produced at the correct price, both the factors being critical for marketing.

Since extension of cultivation takes place from this stage, it is of vital importance to do a complete study of all agronomic and commercial aspects relating to any given essential oil at this stage so as to ensure technical and commercial viability during the actual production.

3. After the establishment of the technical and commercial viability of any given crop, its future projected demand is estimated again in conjunction with the international and domestic trade and industry so as to establish the initial area in which the crop must be planted.

4. Simultaneously with the planting of the crop in the required area, the desired steam distillation equipment is set up in accordance with the existing international practice for that particular oil.

Depending on the given situation prevailing in any country, the equipment may be domestically procured or obtained from recognised suppliers, in the international centres.

Here again it must be borne in mind that were distillation of the oil or cultivation of the crop is not enough. Both the operations must be carried out in the optimum manner so as to ensure that essential oils of the correct quality are produced. As before, collaboration with the domestic and the international trade and industry remains of vital importance since slight changes in the chemical engineering aspects of the steam distillation equipment being used or the technique of steam distillation itself can lead to unacceptable changes in quality, which in the end leads to the essential oil losing its market.

As a matter of general practice it may be remembered that in those countries where domestic markets for essential oils do not exist, it is normal for a local producer to associate himself with an international perfumery house and contract to sell his entire production to the concerned perfumery house. The result of such an arrangement is mutually beneficial, as may be seen from the following points:-

Advantages to the local producer

1. Input and continuous updating of technology

2. Assurance of market for the goods produced

3. Optimum utilisation of resources for the purposes of maximising production

4. Stability in the long term

Advantages for the International partner

1. Assured source of supply for a required raw material

2. Supply of raw material at the most economic price

3. Assurance of quality and quantity

4. Consequent advantage in international trading in terms of supply of the concerned raw materials at the best price.

5. With the establishment of cultivation and distillation, the production of the the essential oil is initiated and once this is done the marketing of the product can be done in many different ways, the most common of which are described below:-

1. Sales of entire produce to a foreign partner: This is extremely common in the developing world. The foreign partner provides equity participation and input of technology in exchange for the sales of the concerned essential oil at prefrential prices.

2. Sales of the essential oil produced to local dealers/brokers:

In many countries such as USA, France and India, a practice is followed whereby the farmer or the distiller of the essential oil takes his material to a so-called merchant-exporter who collects the essential oil from various suppliers, bulks it together into single large lots, assesses the quality and upgrades the material if necessary. Such a dealer is usually fincancially strong and can hold the material or keep it in stock till he gets the desired price.

The disadvantage of this system is that the farmer or the distiller of the oil does not get the best price and the major part of the profit accrues to the dealer. The advantage of the system is that in the absence of any direct contact with the industry, the farmer is still able to engage in the essential oils trade and in regions where alternate crops are less viable, he can cultivate essential oil bearing crops. In such cases, the farmer usually distills the oil himself using a Field Distillation Still. Since the dealer/broker will usually collect the essential oil from the field of the farmer, the farmer is saved the overheads of packaging, storage and marketing. This practice is usually followed where large areas or plantations are not available for cultivation with a single farmer and the essential oil bearing crop is being cultivated by a large number of small farmers spread over the same geographical area.

3. Sales by local dealers to International as well Domestic Industry

The local dealers, as described above, who collect oil from farmers/distillers bulk the oil into large lots after assessment of quality, pack the material and store it suitably.
This material is the offered on a lot sample basis to established International Dealers/Brokers, a complete list of whom is given elsewhere in the report. These international dealers/brokers maintain liason with the major fragrance/flavour industries of the world and have at all times enquiries from such industries with them. On the basis of offers from various dealers all over the world, they are able to source the material required by their customers. After the sourcing has been done, samples are submitted to the potential buyers and in the event of quality and price being agreeable to the buyer, a contract is arranged by the international dealer with the buyer. After the establishment of the contract, the international dealer at his choise may either buy the material on his own account and make the supply to the customer or he may arrange a direct shipment from the local dealer to the customer.

The local dealers also offer the material directly to the potential consumers because many fragrance/flavour compaines whose consumption of certain raw materials is very large prefer to source the materials directly from the producing countries. Such contacts are however limited to only a small number of companies and a small number of bulk oils. As before the local dealer remains fully responsible for the quality and the contracted quantity and supply of goods within the stipulated period.

In exactly the same way, in countries where there is domestic consumption of essential oils or where there is a domestic fragrance and flavour industry, the local dealers make offers to the domestic industry and vis a vis the local industry fulfill the same role that the international dealers/brokers do in relation to the international industry.

The following principals should be borne in mind while embarking upon any marketing effort in the field of essential oils:-

1. Essential oils should be produced only after the demand, supply and price situation prevailing in the world market, is determind.

2. On the basis of the price prevailing for the given essential oil, the feasibility of cultivation of the crop and extraction of its oil should be ascertained by back calculating from the international price and converting it into the local calculation. The usual criteria is that the annual average realisation in local currency from the essential oil bearing crop per acre/hectare of the land should more than other competing food or cash crops.

3. I the feasibility of production is established, then on the basis of the projected demand the requisite area should be planted with the given crop.

4. Once production of an essential oil is initiated, it must be ensured that the production results in essential oils which fully meet the prescribed international standards or the specifications agreed to between the buyer and the seller.

5. Compliance with standards includes the usage of the correct type of packaging which should be compatible with the type of oil and the quantity being shipped and the mode of transportation.

6. After the sale has been negotiated either on the basis of an agreed specification or a lot sample or both, it is necessary to ensure that only goods of the quality contracted for are actually shipped.

7. Shipment of the contracted quality and that too within the stipulated period is essential. In the essential oils trade, all primary sales are made on the basis of legally binding contracts which have to be fulfilled irrespective of the change in the market sitation.

Strategy to be adopted in the case of Ethiopia:-

As far as the case of Ethiopia is concerned, it is of atmost importance to establish the following factors:-

1. Variety of crops that have a potential in the world market

2. Feasibility of cultivation in terms of the realisation per acre in Birr terms as compared to the existing crops like maize or teffe.

3. Only those crops should be taken up for cultivation where the feasibility has been clearly estaablished. Various factors of Government policy will have an effect on this assessment and it is upto the local authorities to take a decision in the matter.

4. Contact should be established with international dealers/brokers and consumers to tie up the sales arrangements in such a manner that the entire production of the various essential oils can be sold to one or more buyers.

This is necessary because of the following reasons:-

1. There is no domestic consumption of essential oils in Ethiopia and as such the entire production will have to be exported. It is usually better to ensure complete sales at a slightly lower price rather than to see unsold goods lying in stock which may well deteriorate with time.

2. It is not expected that very large volumes of essential oils will be produced in Ethiopia because of under-utilisation of the existing fertile land and general lack of irrigation facilities. As such in the long run it will be more profitable to dispose off the entire quantity produced to a small number of customers at a slightly lower price rather than to try to find a larger number of customers who will buy smaller quantities at higher prices.

5. After the establishment of contract with the international buyers, the appropriate quantities of essential oils should be produced under contract so that the sales assured right from the beginning.

ANNEXURE 15

THE DEVELOPMENT OF THE ESSENTIAL OILS INDUSTRY IN ETHIOPIA

1. The deliberations of the Expert revealed that Ethiopia had considerable potential for the development of an Industry based on Essential Oils. The interest was intense, a featurenot difficult to comprehend. The nature of the industry is such that it would be an attractive propc ition for countries planning their economies with factors such as:

Rural sector development;
Import-substitution and development of agro-based industry;
Achieving scientific and technological competence in selected areas as some of their desired goals.

Further, the industry is ideally suited to be initiated into developing countries although the products are primarily utilized by the industrial nations. There are however a plethora of problems and concerns upon which National Chemical Corporation should deliberate. Some of these problems are outlined below together with some proposals, all of which emerged during the Expert's mission.

2. Cultivation aspects of Aromatic Plants:

Although the spontaneous flora within Ethiopia may yet contain a considerable number of unknown sources of perfumery and flavour materials, and the screening of the wild flora of a country for such, is of prime importance, ideally aromatic plants for industrial use must also be systematically cultivated.
According the following considerations bear relevance:

Selection of appropriate plant species and procurement of suitable planting material. Maintenance of herbarium vouchers of plant specimens for authentication.

Introduction of modern plant breeding techniques. Study of the special techniques applicable to aromatic plants.

Studies on plant deseases and plant pests and methods to combat such.

Studies on the most economic methods of maintaining the nutrients in the soil and its quality, with minimum use of fertilizer.

Problems of irrigation

Studies on the methods and conditions for harvesting each species of aromatic plant, and the optimum post-harvest prearation of raw material for distillation or extraction, in relation to both quality and yield of oil.
Genetic improvement of crop varieties

3.
Technological aspects

The technology concerning the production of essential oils is well known.

In fact quite simple and elementary distillation outfits are known to produce, in capable hands, very acceptable products. There are several factors here that merit consideration, such as the following:

Decisions regarding the appropriate type of distillation or extraction unit, and location of such.

Methodology of procurement of technological expertise appropriate to a given situation.

Interlinks between the production process of the raw material, and the processing requirements, i.e. optimisation of the time and capacity of the distillation unit in relation to the available raw material.

Fabrication of still units in the country optimisation of conditions and operational parameter

Central supporting R and D Services for quality control of product.

4. Managerial Aspects

The managerial aspects of the production of essential oils relate to management of farms, distilleries and the marketing process. The methods adoped will very much with the country and its special features. In general terms all or some of the following factors may need consideration in most instances.

Availability of adequate extension services as regards agronomic and technological needs methods by which such extension services are made to reach farmers, operators of field distillation units, and those who collect and transport essential oils to centres of marketing.

Measures to ensure adequate control of authenticity and quality of raw material used in distillations

Availability of prompt maintenance facilities for distillation assemblies

Training of all grades of personnel in the industry

5. Storage and Marketing of Produce

One of the most important needs is adequate storage and marketing systems for products. It is established that market price fluctuations and variations in demands for products present considerable problems to producers. Hence the factors below emerge as some needing considerations depending again on the country and the circumstances:

Procurement of appropriate storage vessels and ensurement against contamination and adulteration;

Dissemination of information regarding market demands, quality, pricing factors, etc.

Organised systems of central collection and primary assessment of produce, to enable farmers to promptly dispose of their produce.

Creation of incentives such as capital support, pricing and marketing guarantees and means of transportation of products from remote field areas;

6. Support agencies and regulatory functions

It is true in practice that the essential oil industry in several countries where it has in recent times flourished has enjoyed the benefit of support agencies and several regulatory advantages. The factors below are some of those considered very necessary for the development of the industry.

Creation of Agencies and practices to ensure the development of the Essential Oil Industry as an income generating operation for rural population;

Establishment of information centres for data on exports, imports, producers, wholesalers, cultivating agencies, distillers etc. and accessible extension services;

Regulatory assistance in the promotion of the use of naturally produced essential oils in preference to imported synthetic substances wherever possible. R and D services to assist such utilization.

Agencies capable of rendering capital support assistance to producers of essential oils.

7. Aspects of Collaboration among developing countries

There is unlimited scope for collaboration among the developing countries on a bi-lateral basis. The collaboration could take several forms some of which are cutlined below:

Interchange of planting material, of essential oil bearing crops;

Exchange of information on various crops, technology and methods of extraction, fractionation, purification, formulation of products, marketing practices etc.

Exchange of personnel between R and D Institutions for training and gaining expertise.

Loan of experts from the countries where the industry is more developed to those where the industry is in the initial stages.

Information on best methods of procurement of suitable technology as regards cultivation and distillation.

Testing of products from developing countries at institutions in other developing countries.

8. In general there was felt a strong need to develop a form of Bulletin or other information source on a regular basis to organisations which were interested in the Essential Oils Industry. The need for the information on agronomic aspect, marketing, technology etc. is clearly there.

ANNEXURE 16

SHORT AND LONG TERM STRATEGIES

ROLE OF RESEARCH AND DEVELOPMENT IN THE ESSENTIAL OIL INDUSTRY

1 The developing countries of Asia, Africa and Latin America constitute a vast area, which has every type of agroclimatic condition capable of supporting growth of essential oil-bearing plants for almost all types of established use viz. in the perfumery, cosmetic and flavour industries of the world. Many of these countries also have vast forest resources , and if propery harnessed, wild plants can be used to generate useful products of a wide variety, including essential oils and oleoresins of industrial value. Some developing countries are already producing certain major essential oils and related products like lemongrass oil from Cymbopogon flexuosus (Steud.) Wats., citronella oil from Cymbopogon winterianus Jowitt palmarosa oil from Cymbopogon martini Stapf.var.motia, Japanese mint oil from Mentha arvensis Linn , peppermint oil from M.piperita L. patchouli oil from Pogostemon patchouli Hook. , geranium oil from Pelargonium graveolens L.Herit., rose oil from Rosa damascena Mill. jasmine concrete Jasminum grandiflorum Linn. and a large number of other essential oils , oleoresins and spices, which include such important products like cinnamon leaf and bark oil and quills from Cinnamomum zeylanicum Blume clove oil and cloves from Eugenia sp. , cardamom spice and oil from Ellettaria cardamomum Maton , ginger oil, and oleoresin Zingiber officinale Rose and pepper spice, oil and oleoresin from Piper nigrum Linn., etc.

2 However, because of lack of sufficient scientific inputs, the yield of these crops has been in most instances static, or has improved only marginally, and the volume of products has lacked consistency . For these and other reasons, the Western World has switched over to synthetic sources for their requirements of perfumery and flavour chemicals for the industry. The constituents for formulation of cosmetics and flavours can generally be produced more economically from synthetic sources , as compared to those from natural plant products. As a result of this competition from synthetic perfumery and flavour industries, the market potential of natural essential oils , specially those from grasses, has declined considerably during the last 20 years. This has prompted some of the countries in the East to pay less attention to Research and Development on these plants, and incertain cases,

food and other cash crops have understandably replaced the essential oil bearing crops.

3 Fortuitously, due primarily to the recent energy crisis resulting in considerable escalation of prices of petroleum products and turpentine oil - basic raw materials for perfumery chemicals , the entire situati has changed.Once again a time has now come when with acceptable Research and Development efforts, the developing countries have the opportunity to compete with synthetic perfumery and flavour industries,given that they are able to increase the production per unit area as well as cut down the cost of production.The Research and Development efforts of developing countries in this area should be directed in the following three lines:

I. SCREENING OF WILD FLORA

4 Intensive surveys of the available wild flora in the various countries can still lead to discovery of : new sources of essential oils,which already have established use; new essential oils of considerable value in perfumery/ cosmetics industry , which have different notes or flavours not known at the present time.

This kind of research has already yielded in Litsea cubeba Pers.- a competitor with lemongrass oil as a source of citral .Several new essential oils, although on a limited scale, have been introduced as a result of recent research efforts in India .These new oils include Skimmia laureola oil (Skimmia laureola Sieb. and Zucc.) , Ferrula oil (Ferrula jaeschkeana Uatke) and Artemisia oil (Artemisia vestita Wall.) .

Production of such essential oils from wild sources would not only provide renewable sources of cheaper raw material, but would also result in better job opportunities for the rural sector of society living near forests areas in the Third World.Such research efforts would yield tangible results only if there is a close collaboration between the scientists and the industrialists in the area of perfumery , cosmetics and flavouring compounds. No scientific inputs would yield commercial results unless the industrialists are involved at an early stage in collaboration in such research programmes.

II. IMPROVING YIELD POTENTIAL OF ESSENTIAL OIL CROP PLANTS OF ESTABLISHED VALUE

5 Most of the essential oil bearing plants grown in developing countries , which include lemongrass (Cymbopogon flexuosus) , citronella (Cymbopogon winterianus Jowitt) , palmarosa oil (Cymbopogon martini Stapf.var.motia) and a certain others,have originally been adapted from wild sources. Although a certain amount of agronomical experiments have been carried out in certain countries , resulting in marginal increases in yield these crops have not yet been subjected to intensive agricultural experiments similar to food and other cash crops, with the result that the yields of these crops per unit area have remained almost static. As a result of this, these essential oil bearing crops, specially grown in the developing countries, have failed to stand up to competition from synthetic perfumery chemicals ar as alternatives to other cash crops.

6 In order to break the so-called "yield - Barrier" , the developing countries would have to treat the essential oil bearing crops on par with other cash crops, and direct their agricultural research on the following lines:

7 - Development of improved agronomic practices:
Modern agriculture can exist commercially only if it can breakaway from the past and develop new agronomic practices by carrying out intensive research on plant nutrition,crop husbandry, water management and weed control. In order to succeed in increasing the yield of essential oil bearing crops, there will have to be scientists and technologists involved in the area of soil-fertility,water-management, crop husbandry and weed control, all of which have become important (in the broad area of agronomy) as specialised sciences.If integrated properly, these efforts can easily result in increases of the present yields by 20 -25% . Ways to minimise cost inputs in cultivation of essential oil crops, which would mean finding out efficient use of nitrogen, phosphorus, potash - the three major fertilizer inputs and

methods for economical use of water specially in those countries where irrigation is required for cultivation of these crops, will have to receive particular attention.
Agronomists in the developing countries would have to strive to use marginal lands for cultivation of some of these crops, which can be easily adapted to grow in the areas having low rainfall or soils affected by high salt concentration.

8 - Genetic Improvement of Varieties:
Comparatively little attention had been paid to improvement of varieties of the essential oil bearing crops presently cultivated; in certain cases the developing countries are actually processing material from plants, obtained from the original habitat. Intensive plant-breeding programmes have to be undertaken for these crops,and is the only practical method to break the "yield-barrier" . On account of modern methods of crop improvement some of the developing countries have succeeded in developing high-yielding varieties of major food crops like wheat,rice, maize and millets etc., as a result of which the yields have increased several fold. Similar increases can undoubtedly be obtained for essential oil bearing crops, if the developing countries decide to take up a planned scientific programme of breeding and intensive agricultural experiments.For this purpose, all interested countries must ensure a good collection of germplasms and a team of competent scientists in the field.There is a case here for free exchange of germplasms amoung countries interested in the development of the Essential Oil Industry.Special emphasis may be laid on crops like lemongrass, citronella and palmarosa as well as geranium, which have low oil contents and considerable potential for improvement . In addition to breeding for increase in yield, attention should be devoted to breeding for quality; specially when a particular constituent is of interest for example: like citral in the case of lemongrass or geraniol in the case of palmarosa oil. The plant breeding programms will also have to include the possibilities of developing varieties resistant to pests and diseases.

9 - Developing Integrated Pest - control Methods:

Diseases and insect-pests do become a problem, when a particular essential oil bearing crop is grown in sizable areas. Such problems become more acute when new crops are introduced in a particular area. For instance a number of diseases have become prevalent, which are posing a major threat to plantations of citronalla, geranium and patchouli in India. Even a crop like palmarosa, which was basically exploited from wild sources in India, suffers from a number of diseases when cultivated on a crop basis. Any research programme will have to include studies on diseases and insect pests affecting these crops, as well as inquiry into economical and efficient methods for controlling them. While developing control measures, less emphasis should be laid on chemical control as a large number of these pesticides are imported into developing countries and can be prohibitive in costs. The development of an integrated pest-control methodology which should include manipulation of agronomic practices, developing resistant varieties and use of pesticides only where considered desirable would be the preferred strategy. In case of diseases caused by virus and nematodes, preference will be on a reliance on plant-breeding methods as against chemical control, as has been done in the case of food crops as well as horticultural crops in many parts of the world.

10 - Development of suitable agricultural machinery

One of the most important methods for reducing the cost of essential oils production, is partial or total mechanization of agricultural operations used in cultivation of such crops. Every country will have to find its own tools adaptable to a particular area, as in case of small farms, bullock-drawn implements may be more appropriate as compared to tractor-drawn equipment. An example of mechanization of agricultural operations in essential oil-bearing crops, has been set by the USSR, where the entire operations right from planting to harvesting have been completely mechanised.

This becomes more important in those countries where there is shortage of labour and cost of labour is increasing. In most developing countries where the situation is reversed labour intensiv methodology will have to be evolved so that the cost of production remains competitive.

III. IMPROVEMENT OF PROCESSING TECHNOLOGY

11 Although a few developing countries use sophisticated distillation equipment, in most of the countries distillation is still carried out by empirical methods. Rarely have any efforts been made to study the various parameters of distillation of different essential oil bearing crops. Distillation of lemongrass may be quite different to distillation of citronella, if studied carefully, and the requirements may be quite different to those methods used in the distillation of mint varieties. Post-harvest treatment of the crop also varies with each essential oil variety and needs research attention.

One of the most important areas is the development of modern efficient and cheap field distillation units, which can be used by small farmers and which lay major emphasis on fuel economy. All producer countries will have to seriously think of developing such field distillation stills which are characterised by mechanisms of re-cycling of energy. This means that such stills should whenever possible utilise the exhausted grass or marc as fuel, so that the use of costly fuel like wood, coal or furnace oils, can be minimised.

Special emphasis should be laid on improving the distillation techniques, storage methods etc. to enable the essential oils to achieve market acceptability.

12 Another area for Research and Development in processing is secondary processing of essential oils or production of oleoresins from spices by solvent extraction. In a country like India, considerable progress has been made in this direction and there are a number of industries producing perfumery, cosmetics and flavour chemicals utilising turpentine oil, citronella

oil , lemograss oil, palmarosa oil, ginger oil and oleoresin pepper oleoresin etc.

However, India still exports the bulk of the raw material in a crude form to several countries in the world. There are frequent complaints from the Western World that spice oils produced in the developing countries are substandard, or at least, not of international standard. This is a challenging area of research for these countries. There is no reason why every producer country should not strive to export natural perfumery chemicals, oleoresins and essential oils as well as spice products, in place of crude raw materials.

13 It is of interest that in a country like India, where considerable development has taken place, most of the celery seed (Apium graveolens) is exported in crude form. Although certain entrepreneurs have taken up the venture to export celery seed oil , they are faced with complaints that the Indian oil is not comparable to that produced by French or British manufacturers of this oil .

A similar situation prevails in the case of patchouli oil, as the French patchouli oil is considered superior to Indonesian oil and sells at a premium price.

14 Whether these assertions are valid or otherwise, scientists in the developing countries should be in a position to solve such simple problems by experimentation, so that in the future their countries are able to earn more foreign exchange by exporting finished products, which can claim to satisfy the most stringent quality requirements. There is now a justification for many of the developing countries to think in terms of R and D for production of perfumes, cosmetics and flavouring compounds based on indigenous raw materials from natural sources.

15 During the last few years certain industrial concerns in India have been able to market their own cosmetics, toiletries and perfumes, like creams and tooth-pastes, in the face of great competition from the industrialised countries. The Indian experience should point a way to other developing countries as well.

CONSIDERATIONS FOR THE FURTHER DEVELOPMENT OF AN INDUSTRY DEALING WITH ESSENTIAL OILS AND AROMATIC CHEMICALS

The main considerations for the further development of an Industry dealing with Essential Oils and Aromatic Chemicals, can be categorised and summarised in the following manner:

1 Selection of plant species for improvement of the essential oil content and quality :

- Selection of the right plant, identification of the same by morphological, chemotaxonomic and chromosomal examination; application of agronomic practices to increase the content of the essential oils and to generate the required quality of oil; mutagenic experiments to evolve improved varieties.

2 Isolation procedures:

Steam and hydro-distillation :

- introduction of improved techniques, creation of centralised facilities for such distillations , introduction of continuous distillation procedure where necessary and appropriate.

Solvent extraction:

- Use of petroleum ether/hexane; butane under pressure ;
- development of the technologies for the latter two systems.
- Application of solvent extraction techniques for isolation of aromatic principles from flowers.

3 Chemical composition of essential oils:
Quality assessment methods:

- Understanding of the total number of constituents present in essential oils, and variations due to geographic, climatic and other factors .
- Application of fractional distillation in the separation of the constituents of an oil:efficiency of a fractionating column; the use of spinning band columns;packed columns;other devices;
- Application of Chromatographic methods for separation of constituents: Column chematography preparative, and analytical, thin layer chromatography.
- Application of analytical and preparative gas-liquid chromatography

and identification of the constituents;

- Combination of gas-liquid chromatography and column chrom ography in the characterization of these constituents .Understanding of the principles behind this technique;
- Detailed understanding of gas liquid chromatography, solid support, stationary phase and its nature , type of column ,length of column, nature of detector, plate efficiency of gas liquid chromatography columns, as this technique is the basis of modern instrumental methods of quality assessment of essential oils and aromatic substances .

4 Application of spectoscopic techniques in analysis:

- Application of infra-red,Raman, visible and ultra-violet spectra for determining the nature of compounds and their estimation;
- Application of NMR spectroscopy;
- Application of mass spectrometry, combination of mass spectrometry and gas liquid chromatography;

5 Organoleptic assessment of quality in Essential Oils and Trade requirements :

- Establishing standards for essential oils and perfumery chemicals;
- Instrumental and chemical methods for estimation of constituents;
- Methodology of organoleptic assessment , its strengths and limitations;

6 Large scale processing of essential oils and perfumery materials:

- Selection of most appropriate technology and conditions;
- Significance of temperature during processing;
- Significance of conditions of purification;

7 Production of perfumery chemicals form Essential Oils :

- Selection of suitable methods and equipment for preparation of semisynthetics via isolates obtained from natural sources;
- Use of products from other sources if available; petrochemicals, coal-tar products ;
- Evaluation of odour qualities of products vis-à-vis standard substances:

PROSPECTS FOR DEVELOPMENT OF ESSENTIAL OIL BEARING CROPS BY GENETIC MANIPULATION

1 All essential oils are naturally synthesized in plants as secondary metabolites. But not all the plant species are endowed with such products. All of them do not possess the same product either.Diversity in essential oils (with respect to their aroma specified by specific chemical constituents and their proportions) is indeed the consequence of diversity in natural flora occuring on this earth. Different countries of the world are gifted with considerable number of plant species that bear essential oils. The wide variety of agro-climatic types within the developing world would surely enable the production of almost every type of aromatic plant species from which essential oils are industrially produced today.

2 The emergence of synthetic substitutes for the naturally occuring perfumery products was the natural consequence of several recent developments discussed in the foregoing chapters.
Nevertheless, natural products firmly hold the promise for the future on two counts: firstly,the quality and aroma of natural products are more characteristic and stable than that of synthetic products , and secondly, natural products can be produced with concerted efforts to be economical enough to compete with synthetic substitutes.

.3 Genetic manipulation affords a new and powerful tool by which natural essential oils may in future yearsbe produced both in quantity and quality. These two aspects may be discussed separately.
The improvement of the yield of oil per unit area of crop coverage may be achieved by increasing the herbage , i.e. fresh green weight (or flower/root yield, as the case may be) of the plant and/or by enhancing the oil content (%); while quality of oil can be enriched by appropriate manipulation of the relative proportion of diverse chemical constituents which confer the requisite quality in a given oil. Though improvement of both these aspects may be possible by adopting suitable crop husbandry there is a threshold limit, imposed by the genetic potential of essential oil bearing plants. Beyond this limit, no amount of agronomic manoeuvering will help. On the contrary, in some cases, a negative return may be harvested. Thus, it is the genetic potential

of the crop that has to be elevated. Agronomy can help only to full realize that potential.

4 Genetic improvement of quality and quantity of essential oils in different plant species has so far been given comparatively little attention . In fact, the whole strategy has hitherto been confined to the exploitation of wild resources or devising suitable agro-technology for realization of exisiting potential of such crops, if domesticated. Obviously, these crops are, by and large , virgin insofar as their genetic manipulation for their betterment is concerned.
Thus, there exist great prospects for elevating their genetic potential through plant breeding .But, how can the plant breeder or geneticist achieve such pragmatic results?

5 There is what is now termed the "Ladder system approach" to plant breeding for crop improvement .This consists of the following steps:

(a) Collection and maintenance of genetic stocks

Diverse genotypes from wild sources or from places where they are grown are collected and maintained. This is, of course, the first requirement of a plant improvement scheme.

(b) Evaluation of Genetic stocks

Desirable or undesirable attributes of different genetic stocks so assembled are identified. Hence they are systematically evaluated for:

(i) Basic information:

- Mode of reproduction and breeding structure
- Genetic diversity and nature of gene action.

(ii) Applied information:

- Oil productivity (yield per unit area)
- Oil content(%)
- Oil quality
- Disease / pest reaction
- Other desirable features like plant-type

(c) Increasing the productivity: productive breeding

To increase the oil-yield per unit area, improvement either in the herb yield or oil content or in both is sought. This is achieved through:

(i) Strain/clonal selection
(ii) Hybridization , if possible, for
  (a) developing hybrids(heterosis breeding)
  (b) isolation of desirable recombinants (Recombination breeding)

(iii) Population improvement (Synthetic/composite breeding)

(iv) Radical means, such as mutation (preferably irradiation) breeding , polyploidy breeding,remote hybridization.

(v) Non - conventional means, such as genetic engineering or bio-culture techniques including somatic cell hybridization,protoplast fusion etc.

(d) Removal of bottleneck genes: protective breeding

Though productive breeding does take into account the disease/ pest reaction of the chosen genotypes; protective breeding becomes expedient if the finally selected genotypes suffer from some newly evolved pathogenic races.Moreover, in some plant species, breeding for disease resistance,is perhaps more consequential than breeding for productivity as such.For instancethe nematode problem in pachouli endangers its commercialization. Selection of nematode resistant clones a priori may increase the possibility of its commercial cultivation. Protective breeding is accomplished through:

(i) backcross breeding
(ii) mutational rectification

(e) Enhancing the quality components: Quality breeding

Improvement in oil-quality is accomplished through changing the relative frquencies of genes(s) responsible for specific chemical constituents conferring requisite quality. This is possible through:

(i) Simple selection
(ii) Judicious hybridization
(iii) Adequate mutagenesis

(f) Minikit and performance trials over environments : Adaptive breeding

Once the final products of a plant breeding programme, namely variety, hybrid or population are identified,they are tested under diverse agro-ecological conditions for their suitability to cultivation and for grower's acceptance.

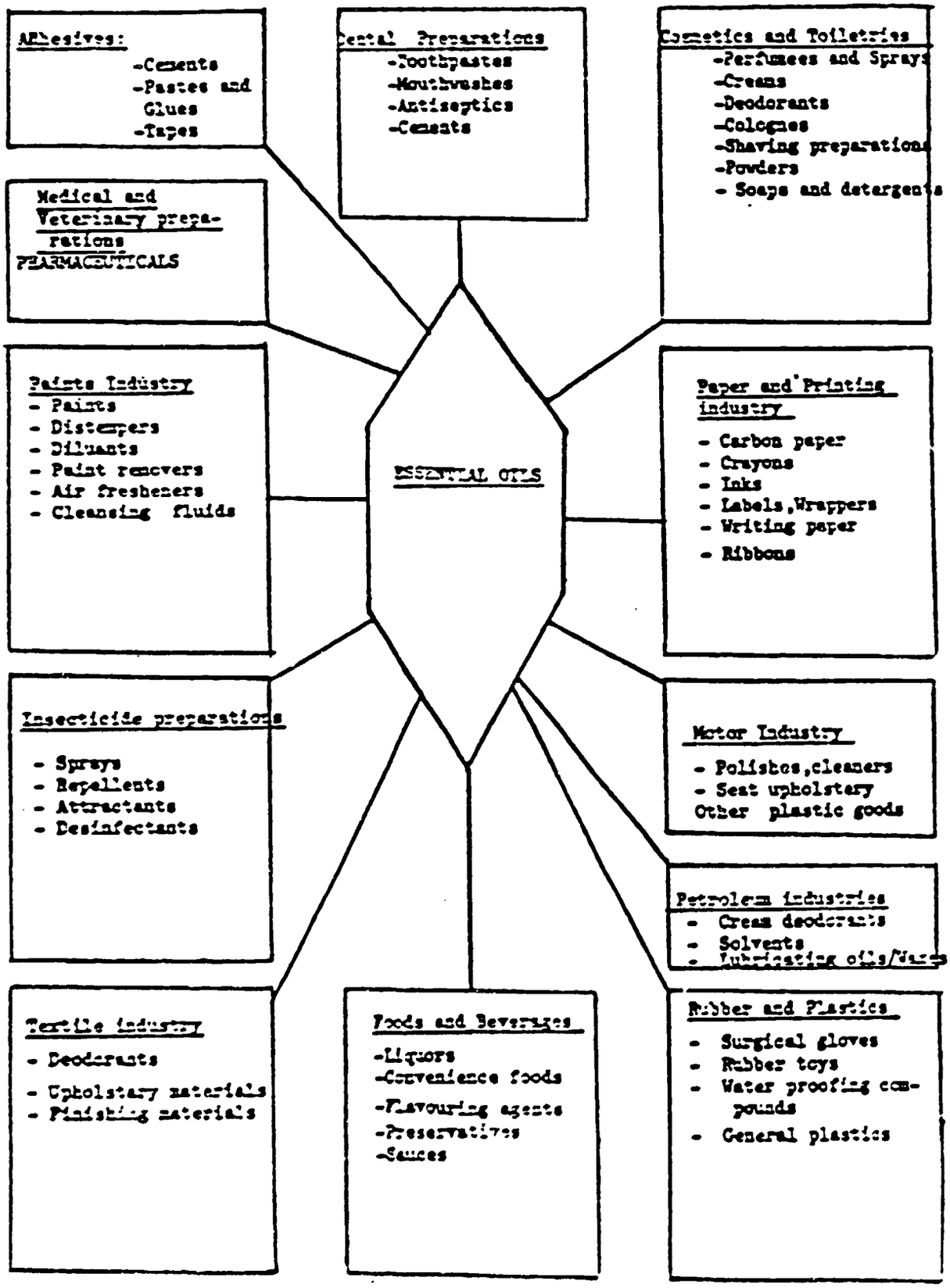
(g) Release of the improved variety for general cultivation

Finally, the variety (or hybrid/population) which has undergone such wide testing graduates to the farmer's field for commercial exploitation. The main advantages lie in a permanent / stable change in the plant for improved quality of oil.These improvements can be brought about by the above means,without

involving musch cost. Indeed, the output/input ratio is tremendously higher in case of the genetic improvement of aromatic plants than that in the artificial reconstitution of essential oils.Thus,by growing genetically improved varieties growers, mostly in rural areas, may augment their income.to a large extent, and in turn,the essential oil industry might well be strengthened too.

ANNEXURE 17

SOME INDUSTRIAL USES OF ESSENTIAL OILS



ANNEXURE 18

MODERN QUALITY CONTROL PROCEDURES

. INTRODUCTION

The United Nations book on World Trade Statistics mentions more than seventy different varieties of essential oils which are produced and marketed commercially. Although the total quantity of these oils would be around a few thousands of tons in terms of money it accounts for a substantial US $ 400 to 500 millions.

Two categories of essential oils are mentioned in this book according to the volume of trade;

(a) The major oils with a large volume of trade. In this category are the following twelve oils of : Aniseed, Bois de Rose, Cinnamon leaf, Citronella Ceylon and Java, Clove, Geranium, Lemon Grass, Peppermint, Patchouli, Petitgrain Sandalwood and Vetiver.

(b) The minor oils in terms of volumes of trade include the remainder of the list of commercial oil number about sixty ranging from All spice Bay and Bergamot to Tarragon Thyme and Valerian.

These essential oils are produced from a large number of different plants growing in many countries around the world. It is quite obvious that variety within each of the species of plants has to be there and such variations may or may not influence the composition of the essential oils they produce. Thus we have to keep in mind that the quality of an essential oil is dependent on one or more of the following factors : the genetic type, the geographical location and climatic conditions of growing, the cultural practices, the method of harvest, post harvest treatment, the type of distillation and equipment used in the production of the oil and finally, the conditions of storage and packaging. All these factors imply that good quality is dependent on the efforts of the grower producer, shipper and consumer who will finally hold the oil in storage for future use. The business of the quality assessor is to examine each specimen and pass judgement on the basis of present parameters which are available for guidance. The producer will benefit from quality control because he knows the quality is good and demands better prices. The buyer will benefit because he will be getting exactly what is required for his manufacturing process.

. THE PURPOSE OF QUALITY CONTROL

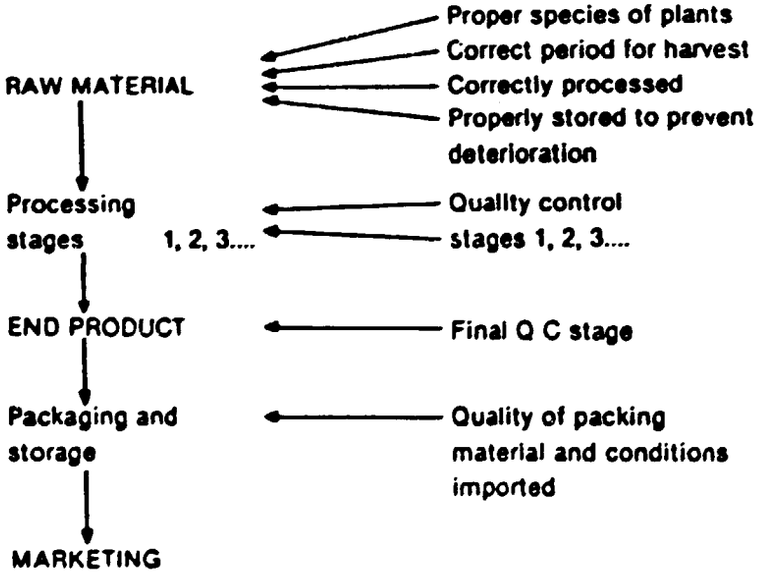
The task in quality control of essential oils is to select the cheapest (most convenient) possible goal – oriented determination of the parameters which would allow producers to come up everytime with the right product having the right properties. These must also reveal if any adulteration and/or substitutions have taken place. Notwithstanding all this if the aroma or flavour are unsatisfactory (un – characteristic) then the purchaser would be still reluctant to buy the oil. As can be seen from the above the mission of quality control today is a complex and manifold one. The practitioner of quality control (the quality assessor) in turn has to have a good practical grounding in basic physico – chemical methods of testing and also some understanding of the applications of instrumental methods in quality assessment. Finally he must also have a reasonably sensitive and selective senses of smell and taste to perform the sensory part of quality evaluations.

The recommended parameters mentioned before are compiled in sets of specifications. Many authorities both in producing countries (majority are developing countries) and consuming countries (mainly the developed West and Japan) issue specifications for essential oils. These may be either official standards or merely recommendations designed to assist quality maintenance and judgement. Among these the British Standards (BS), the Indian Standards (IS), the German DIN Standards, the French AFNOR Standards, the Essential Oils Association (EOA) U.S. Standards and the International Standards Organisation (ISO) specifications are the most important. Many others including the British Pharmacopoeia (BP), the U.S. Pharmacopoeia (USP) and the European Pharmacopoeia can be mentioned. Most of these specifications contain the physical constants such as refractive index, specific gravity, optical rotation and specific rotation; non – volatile residue, solubility in ethyl alcohol (ethanol or

appropriate strength), relevant to each type of oil : The chemical parameters include the acid value, the ester value after acetylation; (the difference of these two will give the value for free alcohol content), the carboxyl value (total aldehydes and ketones) and the phenol content. Many of the more important specifications include data on gas liquid chromatographic (GLC) analysis both qualitative and quantitative. However it must be emphasised that physico – chemical data alone cannot give more than a basic indication of the true quality of an essential oil, it is only by coupling this with the sensory evaluation that a complete overall picture of quality be obtained. For instance most freshly distilled oils answer all the quality tests flawlessly and the GLC analysis show a perfect specimen yet a trained nose will detect the unusual top – note quite commonly observed in freshly processed oils. It is only after a few weeks under good storage conditions that the characteristic odour of the individual oil can be noted.

It is well known that quality assessment starts at the raw material stage in most processing industries. In the essential oil industry too raw material of guaranteed quality is one sure way of obtaining quality assured final products. Since raw materials for essential oils give yields ranging from 0.5 – 6% by weight (exception being clove buds 11 – 15%) there is corresponding increase in the value of final product. Therefore selection and grading of the starting material is well worth the extra time and money spent because, all other things remaining equal. Good raw materials give higher yields and superior quality essential oils.

THE QUALITY CONTROL STAGES



A typical standards specification sheet would appear as follows:

	Specifications	
Botanical Nomenclature	*Cinnamomum zeylanicum*, Nees.	
Other General names	The oil of commerce is characterized by its geographical origin: Cinnamon leaf oil Seychelles, Cinnamon leaf oil Ceylon.	
Preparation	By steam distillation of the leaves and twigs	
Physical and Chemical Constants		
	Ceylon type	*Seychelles type*
Colour and appearance:	Light to dark brown	Light to dark brown
Specific gravity @ 25/25°C:	1.030 to 1.050	1.040 to 1.060
Correction:	.00071 per °C	.00071 per °C
Factor :	(n°/n°C.)	(n°/n°C)
Optical Rotation:	+ 1 to − 2°	0 to − 2°
Refractive Index @ 20°C:	1.5290 to 1.5370	1.5330 to 1.5400
Eugenol :	80 to 88%	87 to 96%
	Processed as directed for the determination of phenols (see determination E.O.A. 1-K). To insure a clear separation first shake a suitable quantity of the oil with approximately 2% powdered Tartaric acid and filter.	
Solubility in Alcohol :	Soluble in 1.5 volumes of 70% alcohol, may cloud on further dilution.	Soluble in 1.0 volumes of 70% alcohol, may cloud on further dilution.
Descriptive Characteristics		
Stability:		
Alkali:	Unstable in alkalis	
Acids:	Strong inorganic acids will tend to cause polymerization, quite to weak organic acids.	
Solubility:		
Propylene glycol:	Soluble in all proportions	
Benzyl benzoate:	Soluble in all proportions	
Fixed Oils:	Soluble in most fixed oils	
Mineral Oil:	Soluble with cloudiness or turbidity.	
Glycerine:	Insoluble	
Diethyl Phthalate:	Soluble in all proportions	
Containers	Should be shipped preferably in glass, aluminium or tin-lined containers. When galvanized containers are used a precipitate may result.	
Storage	Store in tight, full containers in a cool place protected from light.	

THE METHODOLOGY OF QUALITY ASSESSMENT

1 PRELIMINARY STEPS

As the essential oils are commodities which are high in value and small in volume, they come under very close scrutiny during their purchase. Therefore the appearance of an oil is of prime importance. Anyone would find a far more aesthetic appeal in a sample of clear golden yellow oil than in a sample of the same oil which is murky or dark brown in colour. So as a first step, a report on the appearance of the essential oil is good starting point. This statement could include other observations such as presence or absence of water suspended matter, sediment etc. Secondly a report on the aroma and sometimes the flavour of the oil should be made. This again is apparent because the majority of these essential oil end up in closely personal items such as perfumes, colognes, lotions, other cosmetics and toiletries such as soaps and talcum powder or as flavours for food, confectionery and a hundred other things.

An assessor of quality has a fairly responsible task at this point because it is on his sensory evaluation that the oil is finally passed for use. Most of important consumers of essential oils employ highly paid specialist called flavourist and perfumes to issue this final judgement on the quality of an oil they would like to purchase. Very few developing countries have such expertise at their disposal so the general quality control chemists have to stand in for the specialist. The only way the required knowledge for sensory evaluation can be gained is by practice using reputed specimen of each of the essential oils in which the individual chemist could be interested. It is very important that the reference specimen that are evaluated for appearance, aroma and flavour are well authenticated and fairly fresh.

Once the preliminary evaluations are completed and the observation recorded the specimen can then be analysed for conformity of physico-chemical parameters.

2 SECTION ONE : PHYSICAL METHODS

.2.1 DETERMINATION OF SPECIFIC GRAVITY (in air)

a. Definition

The specific gravity (S t/20°C in air)* of an essential oil is the ratio of the weight in air of a given volume of the oil at t°C to that of the same volume of water at 20°C, the weighing being made with weights adjusted to balance brass weights in air.

b. Procedure

Calibrate a specific gravity bottle or pycnometer (of capacity at least 10 ml) as follows:

Clean and dry the bottle or pycnometer and weigh it; fill it with freshly boiled and cooled distilled water and keep it in a bath of water at 20°C until it reaches that temperature. If a bottle is used, insert the stopper in such a way that the capillary is completely filled with water, and then maintain it at 20°C until no further alteration in volume occurs. Wipe the stopper. If a pycnometer is used, adjust the volume of liquid to the fixed mark. Remove the bottle or pycnometer, dry the outside, and weigh.

Empty and dry the bottle or pycnometer. Fill it with the sample of oil previously brought near to the temperature t°C, until it has attained that temperature. If a bottle is used, insert the stopper in such a way that the capillary is completely filled with the oil and then maintain it at the temperature, T°C, until no further alteration in volume occurs. Wipe the stopper. If a pycnometer is used, adjust the volume to the fixed mark. Remove the bottle or pycnometer, dry the outside, and weigh.

c. Calculation

$$\text{Specific gravity (S t/20°C) in air} = \frac{W_2}{W_1 [1 + \alpha(t-20)]}$$

where W_1 = weight, in grammes, of water obtained in calibration test,
where W_2 = weight, in grammes, of oil obtained in the test,
and α = coefficient of cubic expansion of glass at the given temperature;
= 0.000 03 for soda glass;
= 0.000 01 for borosilicate glass.

2.2 DETERMINATION OF OPTICAL ROTATION

a. Definition

For the purpose of this determination the optical rotation of an essential oil is taken as the angle in degrees through which the plane of polarization is turned when plane-polarized sodium light is passed through a layer of oil, 1 dm in thickness. The notation is optical rotation α_D^t, t being the temperature (°C) at which the determination is made.

b. General

The determination should be carried out in a dark-room, using sodium light. Any recognized type of polarimeter may be used. The standard temperature for the expression of results is 20°C.

When the determination is carried out at any other temperature, this temperature should be recorded together with the observed rotation. This is particularly important in the case of oils of high optical rotation.

c. Procedure

Switch the light source on and wait unit full luminosity is obtained. Fill the polarimeter tube with the essential oil at the required temperature, ensuring the absence of air bubbles. Place the tube in the polarimeter; read the dextrorotatory (+) or laevorotatory (−) optical rotation of the oil on the scale of the instrument. Allow ample time for the oil and the observation tube to attain a steady temperature before taking readings.

As far as possible make determinations using 1 dm tubes. In the case of dark-coloured oils or oils having a high rotation, e.g. above 90°, a shorter tube may be used, whilst with light-coloured oils or oils of low rotation the determination may be made in a longer tube, calculating the results to a length of 1 dm in each case. The tolerance in length on all tubes shall be ± 0.05 mm.

d. Expression of Results

Record the results in degrees. Take the average of at least three readings, which should agree within 0.08°, and round to the first decimal place.

2.3 DETERMINATION OF REFRACTIVE INDEX

a. Definition

For the purpose of this determination, the refractive index of an essential oil is taken as the ratio of the sine of the angle of incidence to the sine of the angle of refraction when a ray of light of wavelength 589.3 nm (the mean of the D lines of sodium) passes from air into the oil.

The notation is refractive index n_d^t, t being the temperature (°C) at which the determination is made.

b. General

The determination may be carried out by any well recognized method, but instruments employing the principle of the critical angle are most often used. 20°C is the standard temperature for the expression of results unless otherwise stated in the specification for a particular oil.

Diffuse white light may be used as an alternative to light from a sodium lamp for instruments fitted with an Amici compensator which has been adjusted, and the instrument calibrated for a wavelength of 589.3 nm. Readings taken with white light are accurate only when a perfectly colourless and sharp line of demarcation is obtained between the dark and light fields.

c. Procedure

Carry out the determination at or as near as possible to the temperature specified.

d. Expression of Results

Record the refractive index at 20°C as a number to four decimal places.

2.4 DETERMINATION OF SOLUBILITY IN ETHANOL

a. General

All essential oils are soluble in absolute ethanol, and many are soluble in diluted ethanol. Frequently, however, the solutions obtained are not clear, and are described as 'opalescent'.

b. Definitions

The terms used for describing the solubility of essential oils are as follows:

- Soluble, or completely soluble, means that the oils form a clear and bright solution in the proportions stated.

Soluble with opalescence means that the solution formed is not entirely clear and bright, but its opalescence does not exceed that of the reference opalescence prepared as described below.

c. Reagents Ethanol, diluted.

The following table shows the strength, as percentages by volume, of the aqueous ethanolic solutions usually employed in the determination of solubilities, together with the corresponding tolerances for relative density, measured at 20/20°C.

TABLE III PREPARATION OF DILUTE ALCOHOLS

Alcohol (per cent by volume) (1)	Preparations for mixing, by mass		
	Alcohol (95% by volume in grammes) (2)	Distilled water (in grammes) (3)	
70	676	324	
80	796	204	
90	927	73	

Solution of reference opalescence, freshly prepared by adding 0.5 ml of 0.1 N silver nitrate solution to 80 ml of 0.0002 N sodium chloride solution and stirring. Add one drop of diluted (25%) nitric acid and observe after 5 minutes. Shield from direct sunlight.

d. Procedure

Place 1 ml, accurately measured, of the oil in a 10 ml or 25 ml stoppered graduated cylinder, and add the ethanol of appropriate strength according to the oil being tested, drop by drop, shaking after each addition, until as clear a solution as possible is obtained at a temperature of 20°C.

If the solution is not clear compare the opalescence against a dark background, with that of the reference opalescence, through equal thicknesses of liquid.

After the oil has dissolved add an excess of the ethanol, as some oils precipitate on further additions of ethanol.

'Solubility in X per cent (v/v) ethanol
= 1 volume in Y volumes, becoming opalescent in Z volumes'

If the solution is not entirely clear, record whether the opalescence is 'greater than', 'equal to', or 'less than' the reference opalescence.

2.5 DETERMINATION OF RESIDUE ON EVAPORATION

a. Apparatus

Water bath with cover having holes of 70 mm diameter and provision for keeping the water level at approximately 50 mm below the cover throughout the test.

Evaporating basin of nominal capacity of 50 ml, made of heat-resistant glass inert towards essential oils, and conforming to the dimensions shown in Figure 1.

b. Procedure

Heat the evaporating basin on the vigorously boiling water bath for one hour, wipe the exterior, place it in a desiccator for 20 minutes and weigh it to the nearest milligramme. Weigh into the basin, to an accuracy of 1 mg, a suitable quantity of the oil (see Table IV), place it on the vigorously boiling water bath, screened from draughts, and heat for a continous period of 5 hours. Remove the basin, wipe it and place it in a desiccator, and after 20 minutes weigh to the nearest milligramme.

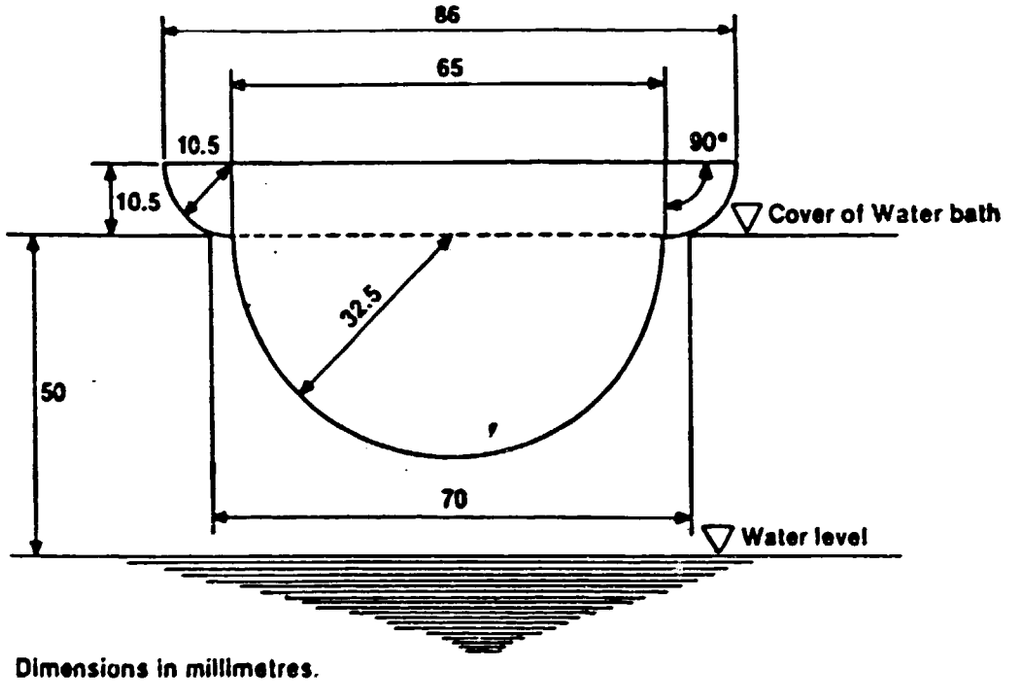
c. Calculation

$$\text{Residue on evaporation, per cent by weight} = \frac{100\,W_2}{W_1}$$

where W_2 = weight, in grammes, of residue,
and W_1 = weight, in grammes, of sample taken
Express the result to the first decimal place.

TABLE IV WEIGHT OF OIL TO BE TAKEN FOR DETERMINATION OF RESIDUE ON EVAPORATION

Expected residue on evaporation	Weight of oil
per cent w/w	grammes
Below 5.0	4.8-5.2
5.0-8.0	2.8-3.2
Above 8.0	1.8-2.2



Dimensions in millimetres.

Figure 1. Evaporating basin for determination of residue on evaporation.

3 SECTION TWO : CHEMICAL METHODS

3.1 DETERMINATION OF ACID VALUE

Note : This method is not applicable to oil of wintergreen and oil of sweet birch.

a. Definition

The acid value of an essential oil is the weight of potassium hydroxide, in milligrammes, required to neutralize the free acids contained in 1 gramme of the oil.

b. Reagents

The reagents used shall be of a recognized analytical reagent quality. Distilled water or water of at least equal purity shall be used throughout.

Ethanol, 95% (v/v).

Potassium hydroxide, approximately 0.1 N ethanolic solution, standardized by titration with 0.1 N hydrochloric acid using phenolphthalein as indicator.

Phenolphthalein indicator, 0.2% solution in ethanol, 60% (v/v).

c. *Procedure*

Weigh into a flask, to an accuracy of 1 mg, not less than 2 g of the oil. Add 5 ml of the ethanol, freshly boiled and neutralized to phenolphthalein. Titrate with the 0.1 N ethanolic potassium hydroxide solution, using 0.2 ml of the phenolphthalein indicator.

d. *Calculation*

$$\text{Acid value} = \frac{56.1 \times N \times V}{W}$$

Where V = volume, in millilitres, of the ethanolic potassium hydroxide solution required,

W = weight, in grammes, of oil taken,

and N = normality of the ethanolic potassium hydroxide solution.

Express the result to the first decimal place.

3.2 DETERMINATION OF ESTER VALUE

Note : This method is not applicable to oil of wintergreen and oil of sweet birch.

a *Definition*

The ester value of an essential oil is the weight of potassium hydroxide, in milligrammes, required to neutralize the acids, liberated by the hydrolysis of the esters present in 1 gramme of the oil.

b. *Reagents*

The reagents used shall be of a recognized analytical reagent quality. Distilled water or water of at least equal purity shall be used throughout.

Ethanol, 95% (v/v)

Potassium hydroxide, approximately 0.5 N ethanolic solution. Prepare by dissolving 33 g of potassium hydroxide in 1,000 ml of the ethanol. Allow to stand and decant or filter the clear liquid.

Potassium hydroxide, 0.1 N ethanolic solution. Hydrochloric acid, 0.5 N solution.

Phenolphthalein indicator, 0.2% solution in ethanol, 60% (v/v).

c. *Apparatus*

Flask, 250 ml capacity, made of chemically resistant glass and with neck terminating in a ground socket. Reflux condenser, having a ground cone for attachment to the flask.

d. Procedure

Weigh into a saponification flask, to an accuracy of 1 mg, a suitable quantity of the oil (see Table 5). Add 5 ml of the ethanol and neutralize with the 0.1 N ethanolic potassium hydroxide solution, using the phenolphthalein indicator. Add to the neutralized solution 25.0 ml of the 0.5 N ethanolic potassium hydroxide solution and boil the mixture under a reflux condenser for 1 hour. Cool, add 20 ml of water and immediately titrate the excess of alkali with the 0.5 N hydrochloric acid, using an addition 0.5 ml of the phenolphthalein indicator. Make a blank determination, following the same procedure but omitting the oil. Ignore any reappearance of the pink colour on standing.

TABLE V WEIGHT OF OIL TO BE TAKEN FOR DETERMINATION OF ESTER VALUE

Expected ester value	Weight of oil (grammes)
Below 50	4.5 – 5.0
50 – 70	3.5 – 4.0
70 – 90	2.5 – 3.0
90—110	2.0 – 2.5
110 – 140	1.5 – 2.0
140 – 180	1.2 – 1.5
180 – 220	1.0 – 1.2
220 – 228	0.9 – 1.0

Calculation of Ester Value

$$\text{Ester value } E = \frac{28.05 \times (B - V)}{W}$$

Where B = volume, in millilitres, of 0.5 N hydrochloric acid required for the blank,

V = volume, in millilitres, of 0.5 N hydrochloric acid required to neutralize the excess of alkali used for the hydrolysis

and W = weight, in grammes, of oil taken.

Calculation of Content of Esters

The percentage of esters present in the oil may be calculated from the formula

$$\text{Esters, per cent} = \frac{EM}{561}$$

where E = the observed ester value,

and M = the molecular weight of the ester.

Calculation of Content of Combined Alcohols

The percentage of alcohols present as esters in the oil may be calculated from the formula (see note):

$$\text{Combined alcohols, per cent} = \frac{EC}{561}$$

where E = the observed ester value,
and C = the molecular weight of the alcohol.

Note : In the above formulae it is assumed that the alcohols are monohydric and the acids monobasic.

4.3.3 DETERMINATION OF ESTER VALUE AFTER ACETYLATION

Definition

The ester value after acetylation is defined as the weight of potassium hydroxide, expressed in milligrammes, required to neutralize the acids liberated by the hydrolysis of 1 gramme of the acetylated oil.

Acetic Anhydride Method

Note : This acetylation procedure is unsuitable for oils containing tertiary alcohols.

a. Reagents

The reagents used shall be of a recognized analytical reagent quality. Distilled water or water of at least equal purity shall be used.

Acetic anhydride, complying with B.S. 2068.
Magnesium sulphate, neutral, freshly ignited.
Sodium acetate, anhydrous, freshly fused and powdered.
Sodium carbonate, anhydrous.
Sodium chloride, saturated aqueous solution, hereinafter termed brine.
Potassium hydroxide, approximately 0.5 N ethanolic solution. Prepare by dissolving 33 g of potassium hydroxide in 1,000 ml of ethanol, 95% (v/v), allowing to stand and decanting or filtering the clear liquid.
Potassium hydroxide, 0.1 N aqueous solution.
Hydrochloric acid, 0.5 N solution.
Phenolphthalein indicator, 0.2% solution in ethanol 60% (v).

b. Apparatus

Flask, 250 ml capacity, made of chemically resistant glass and with a neck terminating in a ground socket. Reflux condenser, having a ground cone for attachment to the flask.

c. Procedure

(i) Acetylation. Mix 10 ml of the oil, 20 ml of the acetic anhydride and 2 g of the sodium acetate in a long – necked, round – bottom 200 ml flask with a ground – glass neck to which is fitted an air reflux condenser of 75 cm length or more. Boil under reflux for 2 hours, supporting the flask on a sheet of asbestos board in which has been cut a hole of about 40 mm in diameter and heating with a small naked flame placed about 25 mm below, and not impinging on, the bottom of the flask, alternatively, the flask may be heated by an electric mantle of a type which avoids the risk of overheating.

Remove the flask and condenser and allow the contents to cool. Add 50 ml of water, and heat the flask and contents, with the reflux condenser in position, on a boiling water bath for 15 minutes with frequent and thorough shaking. After cooling, transfer the contents of the flask to a separating funnel, and reject the lower aqueous layer. Then wash the acetylated oil successively with :

A. 50 ml of brine;
B. 50 ml of brine containing 1 g of sodium carbonate in solution;
C. 50 ml of brine;
D. 20 ml of water.

Shake mixtures A, B and C vigorously, but conduct the final washing with water with gentle shaking only. If the washing operations have been properly conducted, the aqueous layer from the second washing should be alkaline to phenolphthalein. (Do not add ethanolic phenolphthalein to the mixture in the separator.)

When the washing is complete, remove the aqueous layer as completely as possible, pour the oil into a suitable container, and dry with 2 – 3 g of the magnesium sulphate for at least two hours, with intermittent shaking. Then filter the oil through a dry paper in a covered funnel.

(ii) Hydrolysis. Weigh into the flask, to an accuracy of 1 mg, the quantity of dried and filtered acetylated oil recommended in Table 6, add 2 ml of water, and if necessary neutralize the free acidity with 0.1 N aqueous potassium hydroxide, using 2 ml of the phenolphthalein indicator. Then add 25.0 ml of 0.5 N ethanolic potassium hydroxide and boil the mixture under a reflux condenser on a water bath for 1 hour; cool the flask rapidly, add 20 ml of distilled water and titrate the excess of alkali with the 0.5 N hydrochloric acid.

Make a blank determination on the ethanolic potassium hydroxide simultaneously with the hydrolysis of the acetylated oil, and under conditions conforming as nearly as possible to those employed therein.

TABLE VI WEIGHT OF OIL TO BE TAKEN FOR DETERMINATION OF ESTER VALUE AFTER ACETYLATION

Expected ester value	Weight of oil (grammes)
Below 50	4.5 – 5.0
50 – 70	3.5 – 4.0
70 – 90	2.5 – 3.0
90 – 110	2.0 – 2.5
110 – 140	1.5 – 2.0
140 – 180	1.2 – 1.5
180 – 220	1.0 – 1.2
220 – 280	0.9 – 1.0

DIMETHYLANILINE – ACETYL CHLORIDE METHOD

Note : This method should be used for oils containing linalool or terpineol.

a. Reagents

The reagents used shall be of a recognized analytical reagent quality. Distilled water or water of at least equal purity shall be used.

Dimethylaniline, free from methylaniline and aniline.
Acetyl chloride.
Acetic anhydride.
Sodium sulphate, anhydrous.
Sodium sulphate, 10% (w/v) solution of the anhydrous salt.
Sulphuric acid, 2.5% (w/v) solution in the sodium sulphate solution.
Sodium hydrogen carbonate, 5% (w/v) solution in the sodium sulphate solution.
Magnesium sulphate, neutral, freshly ignited.

b. Apparatus

Flask, 250 ml capacity, made of chemically resistant glass and with a neck terminating in a ground socket.

Reflux condenser, having a ground cone for attachment to the flask.

c. Procedure

Introduce 10 ml of the oil into a 100 ml glass – stoppered conical flask and cool in melting ice.

Add 20 ml of dimethylaniline to the cooled oil and mix thoroughly; then add 8 ml of acetyl chloride followed by 5 ml of acetic anhydride. Keep the flask in an ice – bath throughout the addition and allow it to remain there for a few minutes when the addition is completed. Remove the flask from the ice – bath and allow it to stand at room temperature for 30 minutes. Immerse the flask for 3 hours in a water bath maintained at 40 ± 1°C. At the end of this time wash the acetylated oil as follows :

twice with 75 ml of the sodium sulphate solution; with 50 ml portions of the sulphuric acid solution until the washings are free from dimethylaniline, as demonstrated by freedom from turbidity when the last washing is made alkaline (at least five washings are necessary); twice with 25 ml of the sodium hydrogen carbonate solution; and twice with 25 ml of the sodium sulphate solution.

Shake vigorously for 30 seconds with each solution and allow to separate. Dry the acetylated oil with 2 – 3 g of the magnesium sulphate for at least 2 hours, with intermittent shaking. Then filter the oil through a dry filter paper in a covered funnel.

Determine the ester value of the acetylated oil as described under (ii) Hydrolysis in Method A. One hour is a suitable time for hydrolysis in the case of oils where the principal tertiary alcohol is linalool but 2½ hours will be required where it is terpineol. In the neutralization of free acidity not more than one drop of 0.1 N potassium hydroxide solution should be required to give a pink colour. Take the first pink colour as the neutral point, as certain esters, for example linalyl acetate, are easily hydrolyzed.

Calculation (Method A and B)

$$\text{Ester value after acetylation A} = \frac{28.05\,(V_1 - V)}{W}$$

Where V_1 = volume, in millilitres, of the 0.5 N hydrochloric acid required for the blank,

V = volume, in millilitres, of the 0.5 N hydrochloric acid required to neutralize the excess alkali used for the hydrolysis,

and W = weight, in grammes, of acetylated oil taken.

Record the result to the first decimal place as 'Ester value after acetylation by the A or B method', according to which method of acetylation was used.

Calculation of Free Alcohols

The percentage of uncombined alcohols present in the original oil can be calculated as a specified alcohol from the formula :

$$\text{Free alcohols, per cent} = \frac{F(A-E)}{561-0.42A}$$

where A = the ester value of the acetylated oil,
E = the ester value of the original oil,
and F = the molecular weight of the specified alcohol.

4.3.4 DETERMINATION OF CARBONYL VALUE

Definition

The carbonyl value of an essential oil is the weight of potassium hydroxide, expressed in milligrammes, that is equivalent to the amount of hydroxylamine required to oximate the carbonyl compounds present in 1 gramme of the oil.

A. Hydroxyammonium chloride method

This method is suitable for essential oils containing aldehydes other than citronellal and also for certain essential oils containing ketones.

a. Reagents

The reagents used shall be of a recognized analytical reagent quality. Distilled water or water of at least equal purity shall be used.

Ethanol, 95% (v/v), free from aldehydes and ketones. Hydrochloric acid, 0.5 N solution.

Potassium hydroxide, approximately 0.5 N ethanolic solution. Prepare by dissolving 33 g of potassium hydroxide in 1,000 ml of the ethanol, allowing to stand, and decanting or filtering the clear liquid. Standardize against the hydrochloric acid, using the bromophenol blue indicator, and running the alkali into the acid.

Hydroxyammonium chloride solution. Dissolve 5 g of hydroxyammonium chloride in 95 ml of the ethanol; add 0.5 ml of the bromophenol blue indicator. Neutralize with the ethanolic potassium hydroxide solution until the solution is green when the liquid is observed in a thin layer, and red when the layer is thick. A lemon – yellow colour should be obtained by adding 0.5 ml of the hydrochloric acid to 20 ml of the solution, and a red colour by adding 0.05 ml of the ethanolic potassium hydroxide to another 20 ml of solution.

Bromophenol blue indicator. Dissolve, by warming 0.2 g of bromophenol blue in 3 ml of 0.1 N ethanolic potassium solution (prepared by diluting the 0.5 N ethanolic solution with 4 volumes of the ethanol) and 10 ml of the ethanol. After cooling to room temperature make up to 100 ml with the ethanol.

b. Procedure

Weigh to an accuracy of 1 mg into a 200 ml glass – stoppered conical flask, a suitable quantity of the oil (see Table VII), add 25 ml of the hydroxyammonium chloride solution. As will be indicated in the British Standard for the appropriate essential oil, either set aside for the time specified or titrate immediately with the ethanolic potassium hydroxide, taking care to avoid going beyond the greenish – yellow colour of the indicator, continuing the titration at intervals of not greater than 5 minutes until the bluish – green end point is reached and no further colour change takes place after a further 5 minutes. If additional heating is required, this will be indicated in the appropriate British Standard.

TABLE VII

WEIGHT OF OIL TO BE TAKEN FOR DETERMINATION OF CARBONYL VALUE

Expected carbonyl value	Weight of oil (grammes)
Below 50	9.0 – 10
50 – 100	5.0 – 6.0
100 – 200	2.5 – 3.0
200 – 300	1.7 – 2.0
300 – 400	1.2 – 1.4
400 – 500	1.0 – 1.1
Over 500	0.8

Calculation of Carbonyl Value

Hydroxyammonium chloride method

Carbonyl value C = volume, in millilitres, of N ethanolic potassium hydroxide used,

N = the normality of the ethanolic potassium hydroxide solution

W = weight, in grammes, of oil taken

and f = a correcting factor when the end – point of the reaction occurs at a pH different from that of N (or 0.5 N) hydroxyammonium chloride.[5v]

Note : For Dimethyl Yellow and Methyl Orange f = 1.008 and for Bromophenol Blue, f = 1.0

3.5 DETERMINATION OF PHENOLS

a. *Reagents*

The reagents used shall be of a recognized analytical reagent quality. Distilled water or water of at least equal purity shall be used.

Xylene. 3° Xylene complying with B.S. 458/1. It should be tested to ensure freedom from impurities soluble in 5% aqueous potassium hydroxide.

Potassium hydroxide, 5% solution. Prepare by dissolving 59 g of potassium hydroxide, in sufficient water to provide 100 ml. Standardize to contain 5.0 ± 0.1 g of potassium hydroxide in 100 ml. The presence of more than traces of silica and alumina can give rise to separation of flocculent matter.

b. *Apparatus*

A 150 ml flask as described in B.S. 676. Before use, thoroughly cleanse the flask with concentrated sulphuric acid and rinse out with distilled water.

c. *Procedure*

Place in the flask 80 ml of the potassium hydroxide solution followed by 10 ml of the oil and shake the mixture thoroughly at five – minute intervals during 30 minutes, at room temperature.

Raise the unabsorbed portion of the oil into the neck of the flask by the gradual addition of more of the potassium hydroxide solution, and facilitate the separation of the oily layer by rotating the flask between the hands and gently tapping. After leaving the flask to stand overnight, read off the volume of unabsorbed oil, taking the bottom line in each meniscus.

Where a small quantity, not exceeding 0.4 ml, of emulsion is formed between the oily and aqueous liquids take a mean reading of this. If an emulsion is formed which will not separate, repeat the test with the addition of 2 ml of xylene to the test mixture before the initial shaking. This facilitates the separation of the unabsorbed oil. Correct the final reading of unabsorbed oil for the added xylene.

Note 1. Oil of bay. With this oil secondary liquid layer frequently occurs at the bottom of the separated non – phenols. Include this in the unabsorbed portion.

Note 2. Oil of clove, in the case of this oil, eugenol and acetoeugenol are both absorbed.

d. Calculation

Phenols content of the oil, per cent by volume $10 \times V$
where V = volume in millilitres of oil absorbed.

ANNEXURE 19

DETAILS OF WORKSHOP IN PERFUMERY FOR EHIOPIAN TECHNICIANS FROM THE ESSENTIAL OILS, SECTOR

The workshop was attended by the following representatives of the National Chemical Corporation:-

LIST OF PARTICIPANTS IN THE WORKSHOP ON FRAGRANCE FORMULATION AND ODOUR EVALUATION.

1. Dr. Tadele Worku
2. Dr. Madehin Zewdo
3. Dr. Mamo Hsepdom
4. Mr. Mulugeta Chane

The details of the topics covered were as follows:

1. Fragrance blending and compounding:

The modern classification of fragrances and methodology of compounding and blending and the principles involved therein were explained in detail.

2. Sensory evaluation of fragrances:

The importance of precise and correct sensory evaluation in industry was discussed in detail. The importance thereof in industry from the technical as well as the commercial points of view was explained.

3. Raw materials in fragrance industry:

The variety of raw materials used in the fragrance industry was discussed and diversity of sources from which these raw materials orignate was discussed and explained. The technical classification of raw materials was also explained and discussed.

4. Applications of fragrances in cosmetics and toilet preparations:

The variety of products in which fragrances are used was explained. The methodology of selection of a fragrance for any particular application and the technical and commercial considerations involved were explained.

5. Nature of international fragrance industry:

Commercial aspects
Trading practices
Marketing techniques

were discussed in detail and the Vietnamese personnel were made aware of the complex nature of international trade in the fragrance industry.

Concepts of standardisation as well as custom production were explained.

The goods and services available in the international market of the fragrance industry were explained in detail.

6. Quality Control

Olfactory assessment and instrumental quality control methods and their technical and commercial importance were explained.

7. Importance of Research and Development

The importance of building up in house facilities was explained as well as benefits accruing therefrom.

The programme of the training course was initiated by the elaborating on some of the theoretical aspects of olfaction and odour quality evaluation.

The salient points of the training course were as follows:

1. Human and Animal Senses.

2. Structure of Human Sense of Smell.
   1. Anatomy
   2. Receptors-structure and position
   3. Olfactory bulb, axons, nerves and grain.

3. Odour Perception Mechanisms.

   1. Molecular structure of receptors (Alpha-helix)
   2. Ofaction theories.

4. Sensitivity of Odour Perception, Minimum perceptible.

   1. Odour threshholds.
   2. Just noticable difference.

5. Personal Abilities of Human Olfaction Sense.

   1. Sensitivity
   2. Odour memory
   3. Odour association
   4. Odour differenciation
   5. Influence of personal condition (health,mood) on above abilities.

6. Odour Description and Odour Classification

   1. History of odour description methods.
   2. Methods of classification
   3. Premary odours
   4. Odour profiles

7. Odour Quality Evaluation

   1. Direct comparision
   2. Triangle method
   3. Duo-trio method
   4. Quality comparative scale.

After establishing in short, the theoretical background of the subject on the basis of the topics elaborated above, the practical side of the training was initiated by the export on the basis detailed below:

1. Fragrance-Industrial.

1. Definition : Any mixture of two or more odoriferous substances, of a type used in industry.

1. of a type used in food	FLAVOUR
2. all others	FRAGRANCES

Thus it was explained that for the purposes of the programme which was mainly concerned with the industrial use of tragrances and/or use of industrial fragrances, it was necessary to abide by the aforementioned definition which is now used internationally as per the Brussels Trade Nomenclature.

2. Uses : Since the programme was concerned with the use of industrial fragrances, the possible use of such products were explained and are listed below :

1. Household Products

Soaps and Detergents
Cleansers
Disinfectants
Polishes
Paints
Adhesives
Air Freshners

2. Personal Products

Cosmetics: Make-up Products
Toilet and Beauty Preparations
Perfumes and Toilet Waters

3. Industrial Products

Dry Cleaning
Leather and Rubber Articles
Artificial Leather
Linoleum
Plastics
Printing Inks, Perfumed Board and Paper
Textiles

4. Agricultural Products

   Insecticides
   Insect and Animal Repellants
   Animal Baits and Attractants
   Veterinary Products
   Cattle Feeds

After detailing the uses of various fragrances, the major classes/categories into which fragrances can be divided were described and the same are detailed below :

1. Green
2. Fruity
3. Floral

4. Aldehydic
5. Leather
6. Woody
7. Chypre
8. Oriental
9. Citrus

ANNEXURE 20

GENERAL SEMINAR ON MARKETING OF ESSENTIAL OILS

RELATED PRODUCTS

1. Fragrance and Flavours Industry : A General Introduction

2. Raw Materials used in Fragrance and Flavours Industry - A General Introduction

3. Importance of Quality Control

4. International Commercial and Trading Practices

SEMINAR FOR NCC STAFF - ESSENTIAL OILS, FRAGRANCE AND FLAVOUR INDUSTRY

1. Fragrances and Flavours

   a. A Perspective of the World Industry

   b. Use of Fragrances and Flavours

2. Technology of Fragrances and Flavours

   Anbit of Skills required

3. Raw Materials used Fragrances and Flavours

   a. Variety
   b. Production

4. Synthetic and Natural Materials

   Advantages and Disadvantages

5. Essential Oils, Resinoids and Oleoresins

6. Quality Control and Olfactory Assessment

7. Use of Olfactory Sense for Creation

8. World - Wide trade in Essential Oils

9. Establishment of Essential Oil and related Industries

10. Marketing of Essential Oils; Trading and Commercial practices followed in the world market.

ANNEXURE 21

STANDARD BOOKS OF ESSENTIAL OILS

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ANNEXURE 22

METHOD FOR CREATION OF AN OLFACTORY ASSESSMENT AND SENSORY EVALUATION LABORATOY FOR NATURAL SYNTHETIC PERFUMERY MATERIALS.

Background:

1. Natural and synthetic perfumery materials such as essential oils, aromatic chemicals, etc, are used primarly for their odour appeal. Although the analytical characteristics which are commonly determined may provide some assurance regarding the chemical purity of an odoriferous substance, they do not necessarily indicate the "purity" of odour. Hence, olfactory evaluation has been practised for centuries and, in the perfumery trade, it has formed the basis of acceptance or rejection of odoriferous materials.

This methodology has been formulated with a view to introduce standard methods of testing for olfactory assessment of natural and synthetic perfumery materials.

2. Olfactory assessment has been the target of some criticism as it is a subjective test. Numerous attempts on basic odour research and, more particularly, on objective measurement techniques have been made from time to time but none of these has so far wide acceptence. Whereas objective methods are the goal of all odour research, there is, at present, no technique which may replace sensory detection and evaluation of odours.

Terminology

1. **Top note**: The initial and primary odour effect perceived by the olfactory nerves on smelling a strip freshly impregnated with the material being tested. The top note(s) is (are) usually of a short duriation and may or may not be coperceived along with the middle note.

2. **Middle note**: The secondary overall odour effect experienced by the olfactory nerves on smelling a strip impregnated with the material after the initial top note has evaporated. It lasts for a longer time on the strip than the top note.

3. **Residual note (Dry-out Note)**: The tertiary odour effect experienced by olfactory nerves on smelling a strip impregnated with a material after the top and the middle notes have disappeared. Besides indicating the lasting character and strength of the material, it may also reveal the nature of the lesser volatile materials.

4. **By note**: An odour effect, additional to the normal pattern of odours associated with the material, experienced by olfactory nerves on smelling an impregnated strip during any stage of evaporation. It is generally regarded as an index of foreign odour and/or undesirable adulterant and alien.

5. **Odour Description**: Due to the absence of precise terms, descriptive words which are subjective in nature are commonly used to express the odour sensations perceived in the top, middle, residual and by-notes. Some of these terms are given below but the list is not intended to be exhaustive:

acid
acrid
aldehydic
amber
animal
balsamic
bitter
burnt
camphoraceous
choking
citrus
cloying
cool
dry
dull
earthy
exalting
faecal
fatty
fishy
floral
fungal
fresh
fruity
goaty
grassy
green
heavy
herbal
honey
intense
leafy
leathery
minty
mossy
mushroomy
musky
musty
nauseating
nutty
oriental
peppery
persistent

phenolic
piney
powdery
pungent
refreshing
sappy
sharp
sickly
smokey
sour
spicy
stemlike
still odour
sulphuraceous
sultry
sweet
tarry
tart
woody

Requirements

General Requirements: The following general precautions are required to be noted.

Selection and Training:Better results are obtained if individuals with a keen sense of smell and ability to distinguish between different odours are selected for training in olfactory assessment.

Fatigue: Continuous smelling causes olfactory fatigue and decreases critical odour perception. To avoid this, the number of samples assessed during a session should be limited as far as is practical. Further, during smelling, the body should be relaxed. Resting for an interval between smelling different samples is also advantageous. If the number of samples to be tested is fairly large, it is advisable to examine last those materials which are known to be pungent or strong in odour.

It should be borne in mind that inability to correctly identify certain odours may arise from natural deficiencies such as specific anosmia. For instance, some people are unable to perceive musky odour.

Bias: The necessity of minimizing all differences between samples other than that of odour in order to prevent the prejudicing of results is stressed. 'Blind' tests should be conducted by ensuring that the markings on the smelling strip do not disclose the origin of the samples.

Time of Olfactory Assessment: The evidence relating to the most favourable time for conducting olfactory assessment is somewhat conflicting. However, the morning appears to be generally favoured. In general, olfactory assessment should be done after a reasonable interval of time has elapsed after a meal or a beverage has been taken.

Freedom from Contaminating Odours: It is necessary to ensure that the hands, nose and smelling strips are free from contaminating odours as these are likely to vitiate the results. It is recommended that the individual responsible for assessing odour should wash his/her hands several times during a smelling session as well as clear his /her nose.

Material Requirements: The following materials, apparatus and environmental conditions are required.

Library of Standard Samples: For each essential oil, aromatic chemical or other perfumery material, there shall be a standard sample of approved odour value.

The standard samples shall be kept in well-stoppered, air-tight, neutral amber-coloured glass bottles and when not in use, they shall be stored in a refrigerator at about 5°C.

The odour characteristics of standard samples are likely to change over a period of time however well they may be stored. Some materials.improve in odour as a result of maturing while others deteriorate because of minute oxidative changes. An alteration in the odour characteristics of standard samples is not desirable and, in such cases, fresh standards should be adapted. Generally, all perfumery materials recommended shelf life and the sample should be changed thereafter.

Ethyl alcohol: Perfumery grade.

Diethyl Phthalate: Perfumery grade.

Smelling strips: These shall preferably be 1 cm wide and 15 cm long. They shall be made from odourless, thin, absorbent paper and shall be sufficiently stiff so that the strips do not bend under their own weight when held in a horizontal position.

Absorbent paper of substance ranging from 100 to 280 g/m^2 is commonly used. Paper is made entirely from the best cotton material, and is usually in the form of cotton or linnen fibre or a mixture of both. It should be free from any trace of chemicals. Also the water used in making such paper should be pure and completely free from odours, chemicals or salts. The paper should be neutral and should have been kept away from odorous materials and environment all the time. These considerations should be useful in evaluating the quality of the paper used for preparing smelling strips.

Smelling strips shall be packed in air-tight, odour-free containers and stored in a clean odour-free room. Those intended for daily use shall preferably be kept in a wide-mouthed glass bottle covered by a beaker.

Strips Stand: A cruciform patterned 3-clip stand, approximately 21 cm high, or any other suitable device, to hold impregnated smelling strips.

Environment: A well-ventilated room, as free as possible from all outside disturbances. Ideally, the temperature and humidity suited are about 20°C and 80 percent RH (Relative Humidity), respectively. The colouring of the room shall be sober and the furnishing restricted. The general environment shall have a restful rather than a distracting effect.

Procedure

One end of each smelling strip shall be clearly marked before use. Dip the unmarked end of one strip (about 0.5 to 1.0 cm) in the material under examination and of another strip to the same depth in the standard sample after it has attained room temperature. For certain perfumery materials, such as fatty aldehydes, absolutes and solids, use 1 to 10 percent solutions in ethyl alcohol or diethyl phthalate for olfactory assessment.

For semi-solids, solids and strong-smelling substances, use the procedure as given below.

For semi-solid materials: The odour of semi-solid materials such as guaiacwood oil, oakmoss resinoid and absolute, labdanum resinoid and absolute, etc, should be taken on smelling strips but only after melting the contents completely under controlled temperature below 100°C preferably on water-bath.

For strong smelling materials: In order to have a better perception, strong smelling substances irrespective of their physical appearance may also be smelt after dilution to about 1 to 10 percent such as indole, fatty aldehydes, etc, using ethanol or diethylphthalate as a diluent.

Hold the strip impregnated with the standard sample at such a distance from the nose that there is incipent yet distinct perception of odour. While smelling, concentrate wholly on the sensations received and make mental observations. Repeat the procedure with the strip impregnated with the test sample. After about a minute's rest, repeat the comparison reversing the order of smelling the two strips. Finally, compare the two strips for their odour in a "blind" test. If a difference in odour is observed, repeat the "blind" test on the two strips five times. Record the observations of each "blind" test.

It is important to note that although the room shall be well-ventilated, the strips kept under examination should not be exposed to a direct draught.

After this initial assessment for top notes, fix the two strips on a stand keeping them sufficiently apart to avoid inter-contamination. Examine the strips periodically by the "blind" test and note the changes in quality and intensity of odour. Continue in this manner as long as the odour on each strip remains perceptible.

Report

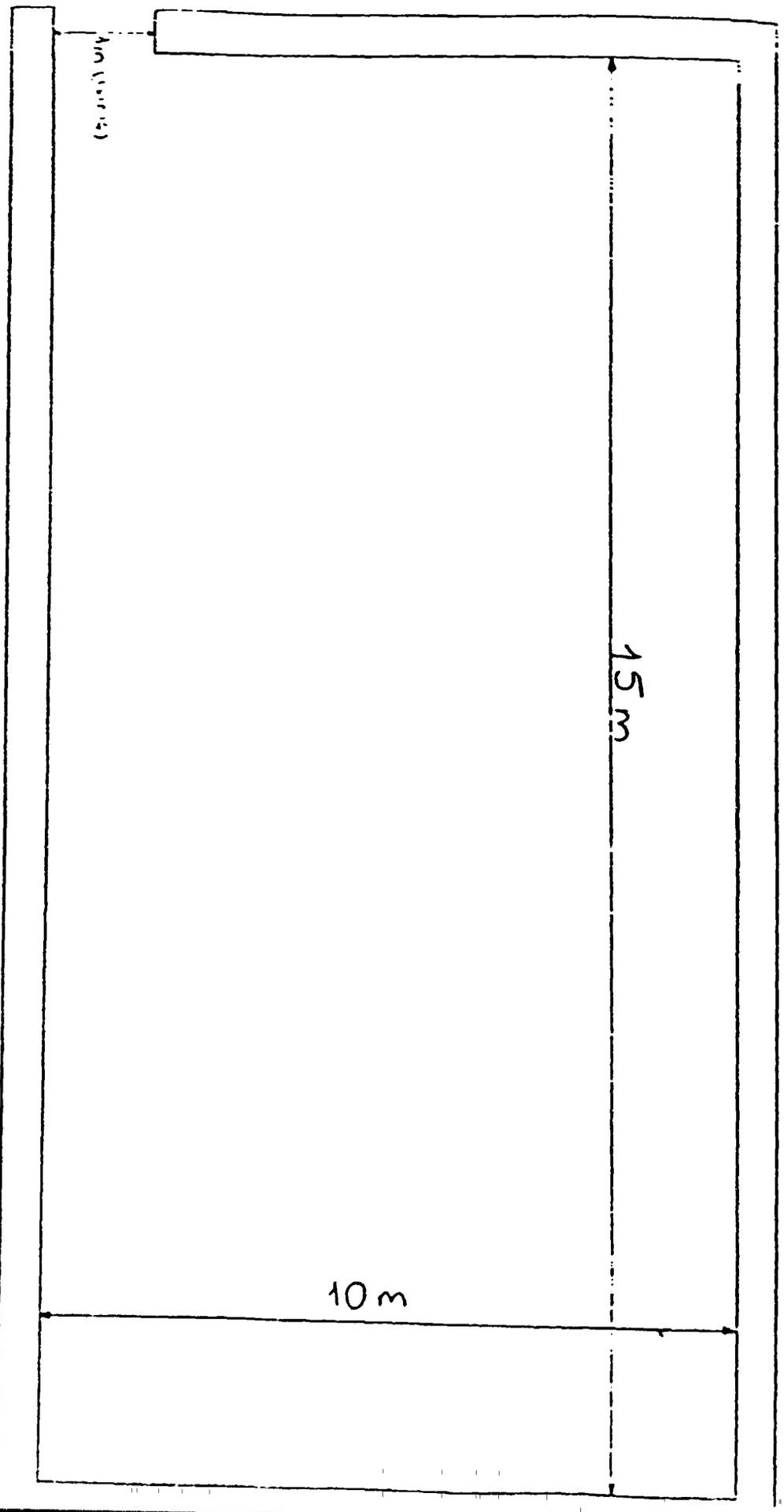
Report the top, middle and residual odour assessment of the test sample as compared with the odour of the standard sample at corresponding stages of assessment.

Criterion for Judgement of Quality: The odour of the material under examination shall correspond to that of the standard at all stages of assessment. If it does not and the pattern of odour is considered to be inferior to that of the standard, the quality of the material shall be regarded as not satisfactory.

Referee Test: In case of dispute, present the individual assessing odour with three suitable coded smelling strips, two of which have been dipped in the material under examination and the remaining one in the standard sample (or *vice-versa*). If the 'odd' sample is consistently picked five times in a 'blind' test, the material shall be deemed to have a pattern of odour different from that of the standard sample.

DETAILS OF FACILITIES REQUIRED IN THE SENSORY EVALUATION AND FRAGRANCE CREATION LABORATORY

1. Refrigerated storage of standard samples of raw materials and finished products.
2. Samples of raw materials in bottles of proper design for daily working.
3. Weighing balances of accuracy to third decimal place.
4. Magnetic stirrer and heater.
5. Water bath
6. Working tables with shelves up the eye level.
7. Efficient exhaust and ventilation system
8. Wash basin
9. Conical flasks, beakers, pipettes, droppers, funnels and aluminium foil.
10. Detached smelling room free from all odours for odour evaluation fitted with an efficient exhaust and filtered air inlet system.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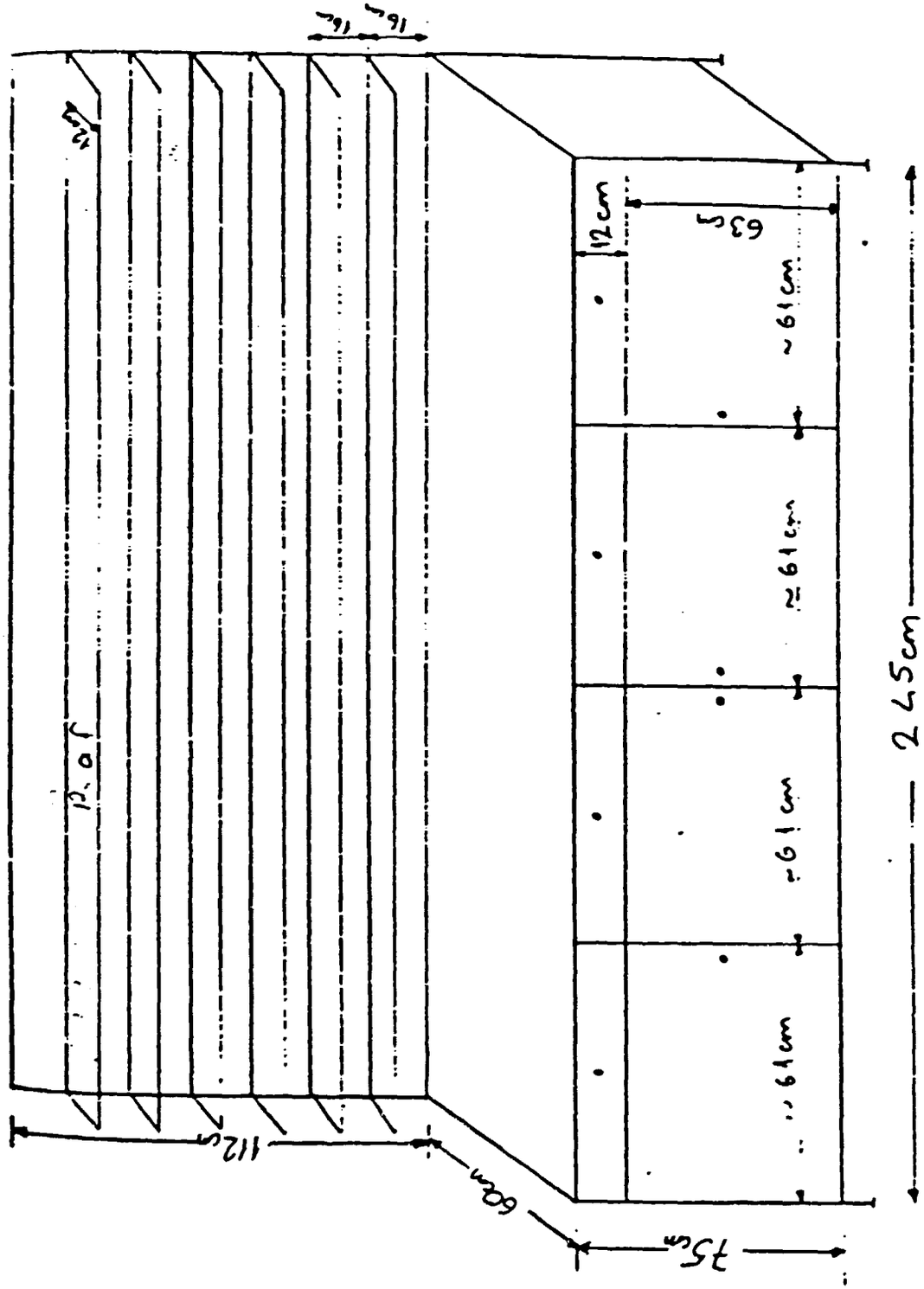
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16cm
12cm
63cm
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~61cm
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245cm
112cm
60cm
75cm

ANNEXURE 23

GLOSSARY OF TERMS RELATING TO NATURAL AND SYNTHETIC PERFUMERY MATERIALS

In the preparation of this glossary, most of the terms currently in use in natural and synthetic perfumery trade and industry together with their synonyms and more common terms in vogue internally and also in other countries have been included.

Terminology

1. **Absolutes:** An ethanolic extract of a concrete or a resinoid which contains the maximum concentration of odoriferous components and is free from natural waxes and/or any solvent used in the processing.
2. **Acid Value:** It is numeric value equivalent to the number of milligrams of potassium hydroxide required to neutralize the free acids present in 1 g of the material.
3. **Alcohol Perfumery Grade, Denaturated:** Rectified ethyl alcohol, specially denatured for perfumery industry, and by the addition of denaturants it thus not at any undesirable by-odours to it.
4. **Aldehydic Blend:** See 13
5. **Amber Note:** A heavy full-bodied warm ambergriss like note.
6. **Animal Note:** Odours or notes with a sensuous character.
7. **Aromatic Chemicals/Aroma Chemicals:** Organic chemicals derived by organic synthesis or as isolate from natural essential oils possessing distinct aroma. Used as raw material for the preparation of perfumery blends or flavours.
8. **Aromatic Plants:** See 92
9. **Aromatic Water:** Aqueous odoriferous condensate of hydro-distilled and/or steam-distilled material of vegetable origin containing fully dispersed essential oil.
10. **Attar (Indian):** A perfume concentrate characteristic of single flower or a mixture of flowers and/or other materials of plant or animal origin with oil of sandalwood as the base.
11. **Balsam:** An odoriferous exudate from plants/trees which flows naturally or is artificially induced by incision.
12. **Blend:** Harmonious combination of two or more odouriferous materials.
13. **Blend Aldehydic:** Blend deriving their unique character from the predominance of aldehydic notes.
14. **Blend,Cologne:** Any harmonious combination of fragrances, the main characteristics of which are derived from citrus oils.
15. **Blend, Oriental:** A blend with heavy, full-bodied sweet balsamic and animal note.
16. **Blend, Spicy:** Any fragrance combination having spicy overtone.
17. **Blend,Woody:** Any fragrance dominated by a woody character.

18. **Body:** Main fragrance theme.
19. **Boiling Range:** See 40
20. **Bouquet:** Generally a harmonius combination of two or floral notes.
21. **By-Note:** A temporary or permanent odour effect additional to the main pattern of odour effect additional to the main pattern of odour associated with the material.
22. **Carbonyl Value:** It is numerically equivalent to the number of milligrams of potassium hydroxide, that is, equivalent to the amount of hydroxylamine required to oximate the carbonyl compounds present in 1 g of material.
23. **Cell:** A unit of the plant tissue
24. **Cellular:** Composed of cells.
25. **Chypre:** A mossy-woody fragrance, complex with a characteristic sweet citrus top note, frequently encompassing some floral tones.
26. **Citrus:** Odours reminiscent of citrus fruits, such as orange, lemon, bergamot, grapefruit, etc.
27. **Cologne:** Name used traditionally for solution of citrus perfume blends in aqueous ethanol (also see 113).
28. **Cologne Blend:** See 14
29. **Concentration:** See 94
30. **Concentrated Perfume:** See 86
31. **Concrete:** A material derived from a single source of vegetable or animal origin by extraction with a suitable solvent. It generally contains non-odouriferous constituents, such as waxes, coloring matter etc, in addition to odoriferous components and is free from any solvent used in the process.
32. **Condensate:** Vapours that have been condensed .
33. **Conderser:** Part of distillation apparatus where the hot vapours are cooled and condensed for recovery.
34. **Congealing Point:** It is the maximum constant temperature at which liquefied solid resolidifies.
35. **Deterpenized Oil:** Natural essential oils which are free from terpenes and/or sesquiterpenes.
36. **Diffusion:** The ability of a fragrance to radiate and permeate the environment.
37. **Distillation:** A process of evaporation and recondensation used for purifying liquids.
38. **Distillation, Dry:** Distillation of semi-solid and solid materials in the absence of steam, water, or any other solvent.
39. **Distillation, Hydro:** Distillation of a substance carried out by indirect contact with boiling water.
40. **Distillation Range:** It is the range of temperature within which a specified percentage of the material distils.
41. **Distillation Steam:** Distillation of a substance by passing steam through it.
42. **Distillation, Vacuum:** Distillation of a substance under reduced pressure.
43. **Distillation, Water:** See 39.

44. **Dry Distillation:** See 38.
45. **Dry Out:** Final phase of the main fragrance after the main volatile constituents have evaporated.
46. **Enfleurage:** Process of extracting fragrance of fresh flowers by intimate contact with mixture of purified fats preferably at low temperatures.
47. **Essential Oil:** It is volatile perfumery material derived from a single source of vegetable or animal origin by a process, such as hydrodistillation, steam distillation, dry distillation or expression.
48. **Essential Oil, Synthetic:** It is a composition generally consisting of natural essential oils, aromatic chemicals, resinoids, concretes, absolutes, etc, but exluding animal or vegetable non-essential oils and not having a non volatile residue in excess of 10 percent by mass. It is so composed that it bears a close resemblance primarily in odour to a naturally occurring essential oil.
49. **Ester Value:** It is numerically equivalent to the number of milligram of potassium hydroxide required to neutralize the acids liberated by the hydrolysis of the esters present in 1 g of the material. It represents the difference between the saponification value and the acid value of the material.
50. **Ester Value After Acetylation:** It is numerically equivalent to the number of milligrams of potassium hydroxide required to neutralize the the acids liberated by the hydrolysis of 1 g of acetylated material.
51. **Evaporation Residue:** Represents the percentage of perfumery material which is not volatile when heated on a steam-bath under specified conditions.
52. **Expression:** The process of extracting essential oil from the plant cells by application of mechanical pressure.
53. **Extract:** A concentrated product obtained by treating a natural perfumery material with a solvent which is subsequently evaporated.
54. **Extraction:** The process of isolating essential oil with the help of a volatile solvent.
55. **Extrait, Alcoholic:** A French word, now universally used in perfumery, meaning an alcoholic extract of odorous parts of a pomade. It is generally used to mean alcoholic solution of a perfume concentrate.
56. **Fixative:** A substance which is compatible with and provides body and substantivity and rounds off a perfume composition by regulating the rate of evaporation of its volatile constituents.
57. **Flavour:** A combined organoleptic sensation of aroma and taste in a flavouring material is also called a flavour.
58. **Floral:** The fragrance characteristic of an existing known flower type.
59. **Fore Runnings:** Initial fractions of the distillate obtained during a distillation process.
60. **Fougere:** Perfume composition having a citrus/lavender top note with sweet powder rosaceous body with mossy/woody background.

61. **Fractionation:** The process of distillation by which an essential oil is separated into various fractions.
62. **Fruit Flavour/Essence:** Suitably blended mixtures of flavouring materials, permitted chemicals and food colours, in a solvent medium of either ethanol or the permitted non-alcoholic solvents.
63. **Fruity Note:** The impression of fruit odours within the fragrance theme.
64. **Full Bodied:** A well-rounded-out fragrance that possess depth and substantivity.
65. **Green Note:** Notes that recall fresh-cut grass, leaves and stems or other parts of plants.
66. **Gum:** A natural water soluble anionic material, often of glycoside-like structure and of high molecular mass which collects in or exudes from certain plants. It forms neutral or slightly acidic solution or a sol with water and has a typical mild odour.
67. **Gum Resin:** Natural exudation from plants and trees consisting of gums and resin with very small amounts of essential oils.
68. **Harmonius:** Order, accord and symphony in a fragrance.
69. **Heavy:** Oriental balsamic as against floral/green.
70. **Hydro Distillation:** See 39
71. **Infusion:** A process of treating a substance with water or organic solvvent
72. **Isolate:** Either a single constituent or a multi-component fraction or a composited fraction, rich in dezired odoriferous components and derived from a natiral perfumery material.
73. **Lasting Qualities:** The ability of a fragrance to retain its character over a given period of time.
74. **Leathery Note:** Any fragrance conveying the dominant characteristic of tanned leather.
75. **Melting Point:** The temperature at which the material melts and becomes liquid throughout as shown by the formation of a definite meniscus.
76. **Melting Range:** The range between temperatures at which the material begins to form droplets and at which it becomes liquid throughout.
77. **Middle Note:** The main overall odour effect experienced by olfactory nerves on smelling a strip impregnated with a material and exposed to the atmosphere for some time.
78. **Mossy Note:** The notes that recall to mind moist dark forest having moss on the trees.
79. **Natural Perfumery Materials:** Perfumery materials of natural origin.
80. **Odour:** That property of a substance which stimulates and is perceived by the olfactory sense.
81. **Oleoresin:** Exudations from tree trunks or barks of trees and are characterized by the fact that these consist of entirely or mainly resin accompanied with an essential oil in varying percentages, soluble in organic solvents.
82. **Oleoresin Gum:** An exudation from plants mainly consisting of essential oil, resin and gum.

83. Oleoresin, Spice: Extractables of spice having resin and essential oil obtained by solvent extraction.
84. Oriental Blend: See 15.
85. Perfume: A solution of perfumery compound/compounds in ethanol or other suitable solvents meant for use as a personal adornment. Here ethanol or other suitable odourless solvents are used as carriers for the fragrances.
86. Perfume Concentrate: A non-alcoholic concentrated perfume blend.
87. Perfumery Compound: A concentrated base which is further diluted with or without toning and further modifications to suit various end-uses.
88. Perfumery Grade Alcohol: See 3
89. Perfumery Material: A naturally occurring substance, or a derived material, or a preparation obtained by physical and/or chemical means, which diffuses or imparts an odour or a flavour.
90. Perfumery Materials, Natural: See 79.
91. Perfumery Materials, Synthetic: See 107.
92. Plant, Aromatic: Plant bearing a characteristic aroma.
93. Pomade: Refined and deodorized animal fat (s) saturated with volatile oils present in and exhaled from the flowers especially the rose and the jasmine.
94. Rectification: Method of separation of undesirable substance to improve the quality of the materials.
95. Relative Density: The ratio of density of material at 27°C to that of distilled water at 27°C or 4°C when all masses are made in air is called relative density at 27°C or 4°C. Originally, it was known as specific gravity.
96. Residual Note (Dry Out Note): An odour effect experienced by olfactory nerves on smelling a strip impregnated with a material and exposed to the atmosphere for a period of time when the top and the middle notes have disappeared.
97. Resin: Solid or semi-solid translucent exudation from trees of plants. These are soluble in organic solvents.
98. Resinoid: A semi-fluid or a solid material obtained from a single resinous source of vegetable or animal origin by extraction with a suitable solvent and is free from solvent used in the process.
99. Saponification Value: It is numerically equivalent to the number of miligrams of potassium hydroxide required to neutralize the free acids liberated by hydrolysis of the esters present in 1 g of the material. It represents the sum of acid value and ester value.
100. Saponification Value After Acetylation: It is numerically equivalent to the number of milligrams of potassium hydroxide required to neutralize the free acid and the acids liberated by hydrolysis of the esters present in 1 g of the acetylated product.
101. Sesquiterpene: Term denoting a hydrocarbon composed of one-and-a-half terpene units, a single terpene unit being equal to two isoprene units.

102.Sesquiterpeneless Oil: An isolate obtained by suitably removing the sesquiterpenes ($C_{15}H_{24}$) from an essential oil.

103.Specific Gravity: See 95.

104.Spice Oleoresin: See 83.

105.Spicy Blend: See 16.

106.Steam Distillation: See 41

107.Synthetic Perfumery Materials: Man-made single perfumery materials, by chemical processes.

108.Tail Running: The last fraction of distillate obtained in a distillation process.

109.Terpeneless Oil: An isolate obtained by removing almost all monoterpenes ($C_{10}H_{16}$) from an essential oil.

110.Thin: The lack of body, richness and substantivity.

111.Tincture: A cold alcoholic extract of the soluble part of a natural fragrant material of vegetable or animal origin, the solvent being left in the extraction as a diluent.

112.Tissue: Plant structure composed of cells.

113.Toilet Water: See 27.

114.Top Note: The first odour effect experienced by olfactory nerves on smelling a strip freshly impregnated with a perfumery material.

115.Vacuum Distillation: See 42.

116.Vacuum Distillation Residue: It is the percentage of material left behind undistilled when a known quantity of the material is distilled in vacuum at specified temperature and pressure.

117.Volatile: A material is said to be volatile when it has the property of evaporating at room temperature when exposed to atmosphere.

118.Water Distillation: See 39.

119.Woody Blend: See17.

120.Woody Note: The impression of wood or woody odours within the fragrance theme.

MODERN TECHNOLOGY FOR THE PRODUCTION OF ESSENTIAL OILS

1. INTRODUCTION

Availability of essential oil bearing plants is more widespread in developing countries whereas the major consuming centres of essential oils are located in the developed countries. Most of the common and high volume essential oils are being processed in the countries of their origin. But many of the high value plant raw materials are being transported to developed countries for the extraction of their essential oils.

Lack of proper know how and processing technology in the producing countries is the primary reason for this. In many developing countries the technology employed for processing of essential oil plants is primitive and obsolete. This reflects in poor quality of essential oils and consequently reduced export earnings. Thus one cannot overemphasise the need for attaining adequate technological capability in the area of processing of essential oil plants.

2. METHODS OF PRODUCING ESSENTIAL OILS

There are broadly four techniques of producing essential oils from plant raw materials :

(a) Steam or Water distillation
(b) Cold Pressing
(c) Solvent Extraction
(d) Extraction with Liquefied Gases

Steam distillation accounts for the major share of essential oils produced. Keeping this in view, various aspects of the technology of steam distillation are being presented in detail in the following treatment. The choice of a particular process for the extraction of essential oil is generally dictated by the following considerations :

(a) Sensitivity of essential oil to action of heat and water.
(b) Volatility of essential oil.
(c) Water solubility of essential oil.

Essential oils with high solublity in water and which are susceptible to damage by action of heat cannot be steam distilled. Also the oil must be steam volatile for steam distillation to be feasible. Fortunately, most of the essential oils of commerce are steam volatile, reasonably stable to action of heat and practically insoluble in water and hence suitable for processing by steam distillation. Some delicate flower oils like those of jasmine, tuberose and violet are damaged by the action of steam and these are obtained by solvent extraction. Most of the spices are processed into their oleoresins by solvent extraction process. Citrus oils like orange and lemon peel oil are best obtained by the process of cold pressing as they are susceptable to damage by heat and moisture.

3. TECHNOLOGY OF STEAM DISTILLATION

Steam distillation is the process of passing steam through a closely packed bed of plant material placed in a tank. Emerging vapours containing the volatile essential oil are led to a condenser for condensation. Condensed water is separated from the immiscible oil in a special vessel called oil separator. Steam may be obtained from an external boiler or produced within the tank by boiling water. Crude essential oil obtained from the separator may be further dried, filtered or centrifuged to improve its appearance and keeping quality.

3.1 WATER DISTILLATION

Water or Hydro distillation differs from steam distillation mainly in that the plant material is almost entirely covered with water in the still which is placed on a furnace. Water is made to boil and the essential oil is carried over to condenser with the steam which is formed. Hydrodistillation is the simplest and the oldest process known to man for obtaining essential oils, from plants. A water distillation still which is in use in India to this day is shown in Figure 1. Still is most commonly made from copper. Another vessel with a long neck is placed in a water tank or a natural pond to serve as condenser. A bamboo pipe is used as the vapour connection and mud is used to seal the various joints.

Water distillation suffers from some serious drawbacks.

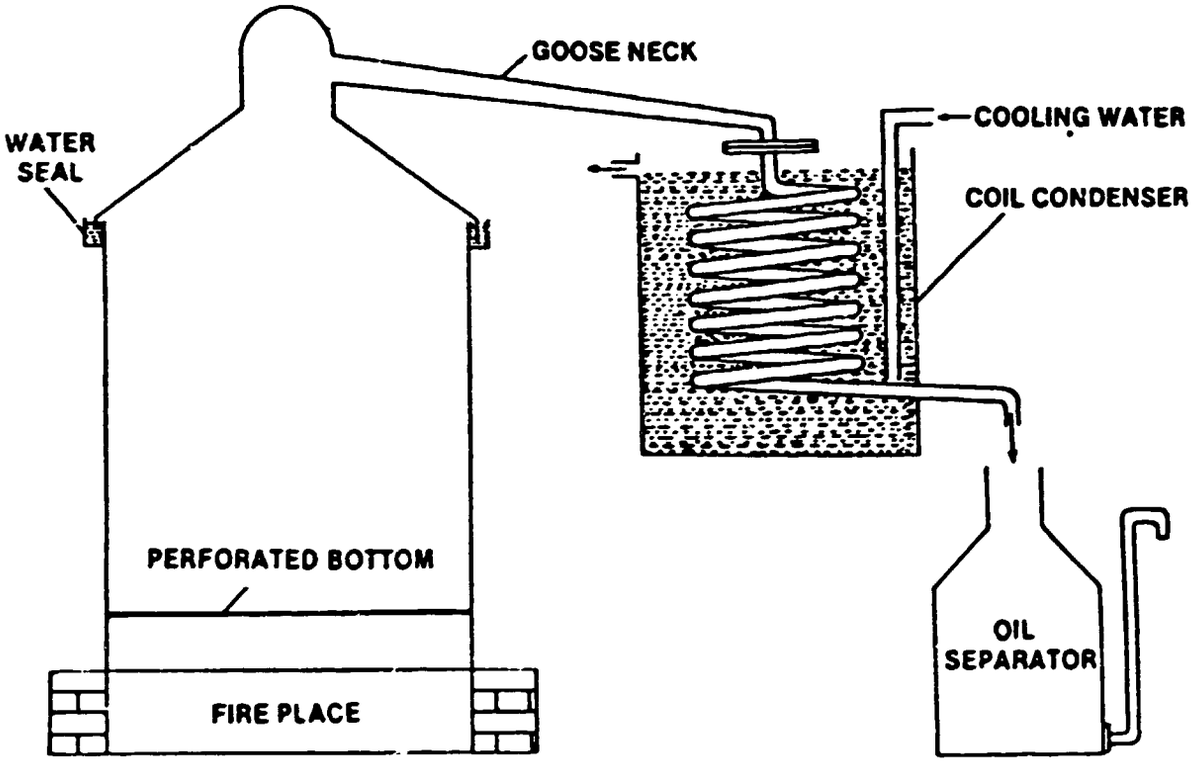


FIG. 2 FIELD DISTILLATION STILL

(a) As the plant material near the botton walls of still comes in direct contact with the fire from furnace, there is the likelihood of its getting charred and thus imparting an objectionable odour to essential oil.

(b) Prolonged action of hot water can cause hydrolysis of some constituents of the essential oil such as esters.

(c) The process is slow and distillation times are much longer compared to steam distillation. Inspite of these drawbacks water distillation is not without its advantages in certain application. Rose flowers are invariably water distilled to obtain otto of rose because if steam is blown through a layer of roses they agglutinate and form an impenetrable mass. Some of the drawbacks of water distillation can be removed if a perforated grid is introduced in the still tc support the plant material as shown in Figure 2. Direct contact of plant material with hot furnace bottom is thus avoided. When the water level is kept below the grid, the essential oil is distilled by the rising steam from the boiling water.

Sometimes this mode of distillation is termed as water and steam distillation. The distillation system shown in Figure 2 is known as Field Distillation Unit.

3.2 FIELD DISTILLATION UNITS

Due to their very simple construction, low cost and easy operation field distillation units are extremely popular with essential oil producers in developing countries. They are mostly fabricated with mild steel or galvanised iron. Furnace is always fueled by locally available fire wood, straw or spent and dried plant material which is being distilled. This makes them eminently suited for location in remote areas where the raw material is available. This helps in reducing transportation costs and economy in the production of essential oils. Field distillation units are currently finding applications in distillation of Patchouli oil in Indonesia lemongrass and Palmarosa oils in India, Citronella oil in Taiwan and many more all over the world. Such field units generally have capacities to hold 200 kg to 600 kg plant material.

3.3 IMPROVED FIELD DISTILLATION UNIT

Due to the limited heating surface available, the rate of steam production in the field distillation units is almost always insufficient. This results in prolonged distillation periods and sometimes lower oil yields. Refluxing back of oil within the still due to less steam rate may lead to some decomposition reactions and poorer oil quality.

Field distillation units are known for their low thermal efficiency. Experimental measurements made a Central Institute of Medicinal and Aromatic Plants (CIMAP), India, have shown that fuel wood consumption in a conventional field still may be up to 2.5 times more compared to a modern steam distillation unit operated by an external boiler. This factor may not be critical where fuel supplies are cheap and abundant. But in many developing countries fuel supplies are getting scarce and costly and low thermal efficiency can directly affect the cost of production.

The above stated defects have been rectified to a great extent by modifying the design of the field distillation unit. The improved design is shown in Figure 3. A number of smoke tubes have been incorporated in the bottom of the still below the water level. Hot flue gasses of the furnace are led through the smoke tubes where they impart heat to the water, thus raising additional steam. Adequate draft is ensured by the use of a chimney which also eliminates smoke nuisance to the operators at ground level. With smoke tubes it is easily possible to double the heating area of the still thus increasing the steam production and ensuring efficient utilization of fuel. Such improved field stills are known to be operating in Taiwan and some parts of India.

3.4 MODERN STEAM DISTILLATION UNITS

Steam distillation exploits the twin action of heat and moisture from steam to break down the cell walls of the plant tissues to liberate the essential oil. As already pointed out the steam in a field distillation unit is at atmospheric pressure and hence its temperature can be maximum 100°C. But steam in a modern pressure boiler operating at say 100 pounds per square inch pressure will have a temperature correspondingly higher. Moreover there is no limitation on the steam generation when an external boiler is used as a source of steam. The use of high pressure steam in modern steam distillation units, such as shown in Figure 4, permits much more rapid and complete distillation of essential oils. A charge of Java citronella which takes up to five hours in a field distillation unit is processed within two hours in a steam distillation still. Fuel costs are generally lower in modern steam distillation units due to higher thermal efficiency at which most of the boilers operate. Capital cost is quite high so that only bigger producers can afford to own such units. Still capacities range from 1 ton to 3 ton plant material per batch. Material of construction could be mild steel, stainless steel

or aluminium depending upon the corrosive nature of the essential oil. Reasonably well – equipped workshop would be required to fabricate these units.

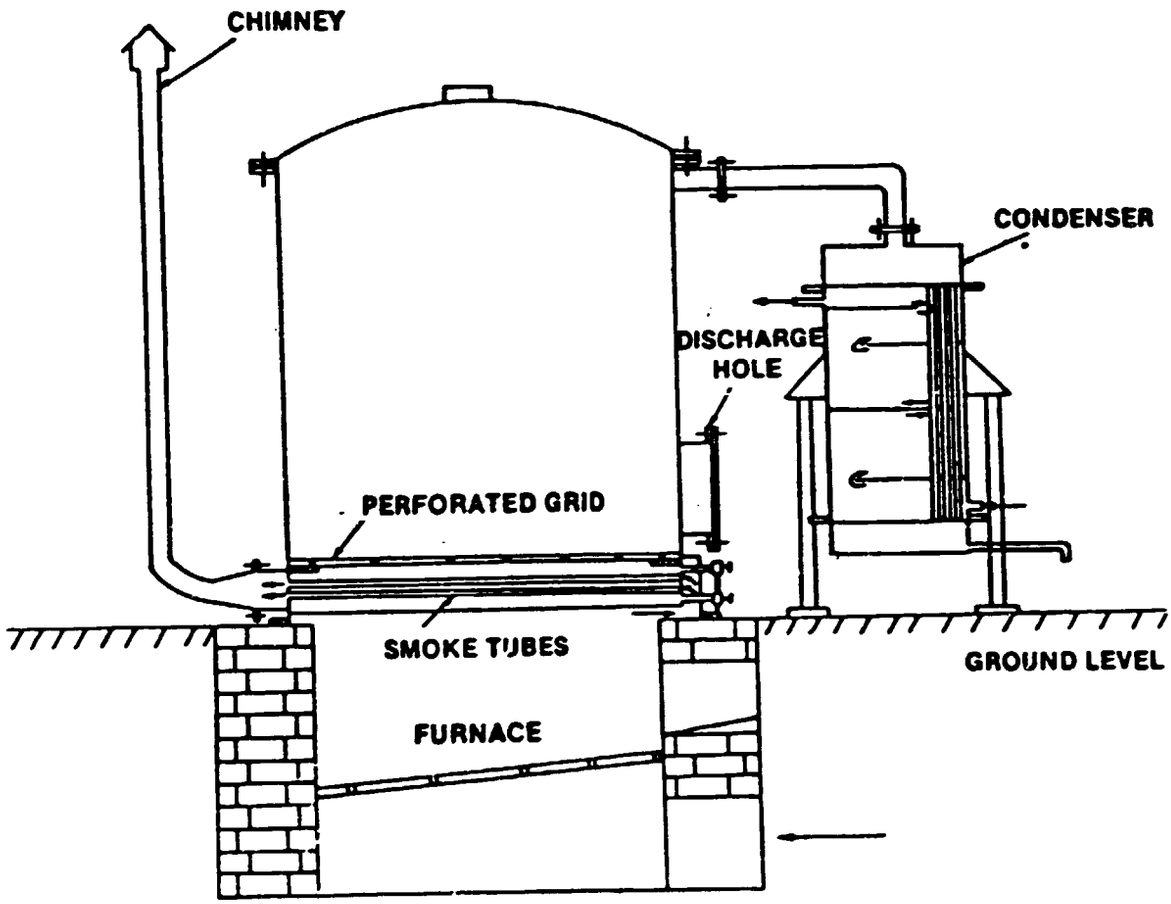


FIG. 3 IMPROVED FIELD DISTILLATION UNIT

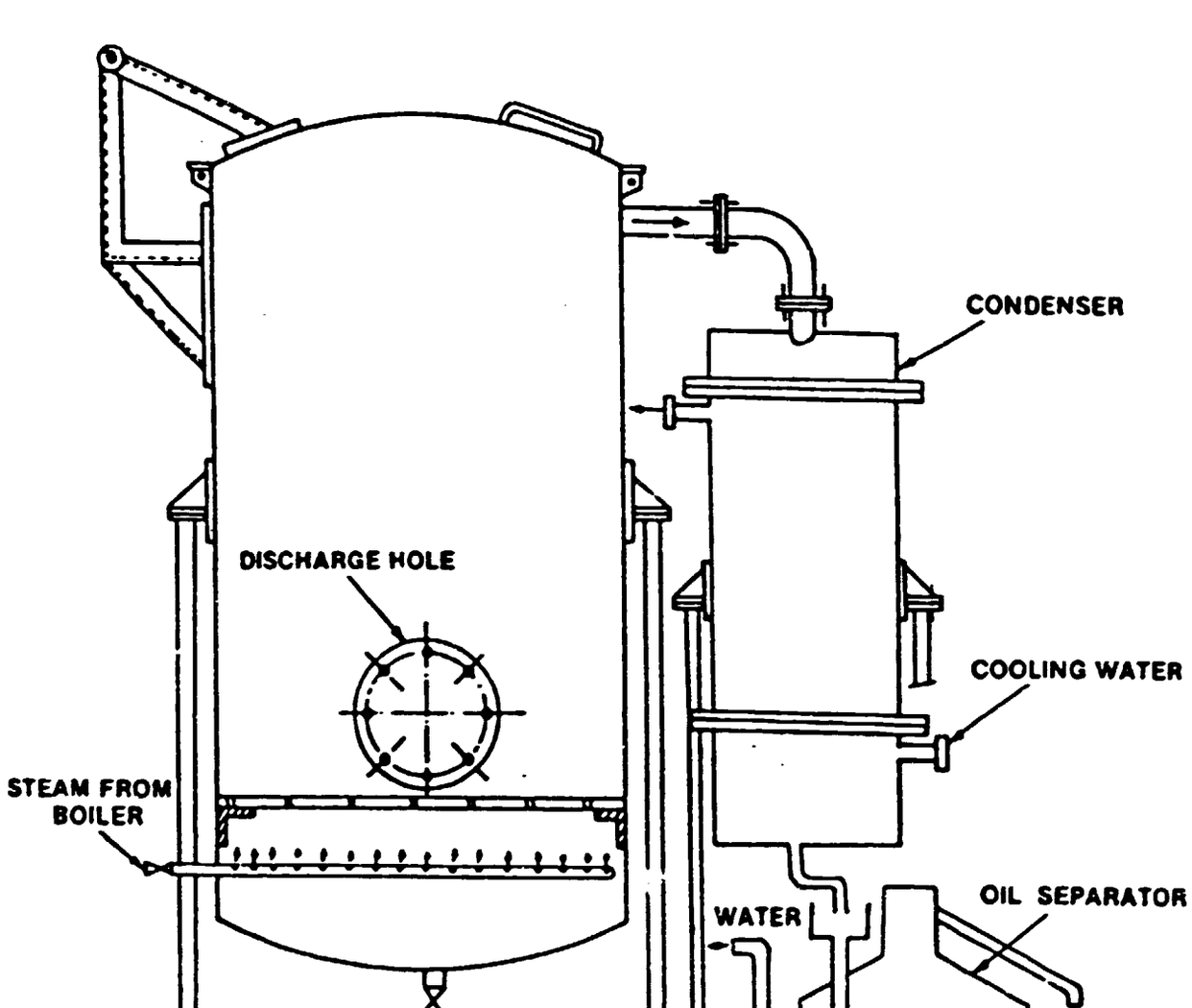


FIG.4 MODERN DISTILLATION STILL

EXTRACTION OF ESSENTIAL OILS WITH VOLATILE SOLVENTS

Delicate essential oils of flowers, like those of Jasmine and Tuberose, are obtained by extracting the flowers with volatile solvents. These essential oils are sensitive to heat and are present in such small quantity that it is not possible to obtain them by steam distillation. Spice oleoresins, which are used as food flavours, are also produced by solvent extraction.

Main features of a manufacturing facility employing solvent extraction are shown in Figure 8. Plant material to be extracted is placed in the extractors provided with perforated grids. Required amount of solvent is then pumped to the extractor from the solvent storage tank. Requisite contact time is allowed for extraction to take place. Extract flows by gravity to one of the extract storage tanks. The charge material may be given upto three washings to complete the extraction. A weak second or third extract is contacted with fresh raw material in the second extractor to yield a rich extract which is sent to evaporator for removal of the solvent. Operation of evaporator under vacuum permits removal of solvent at low temperature which minimises thermal degradation of the product. Flowers on solvent extraction yield a semi – solid product called "concrete" which contains along with the essential oil other soluble plant products like waxes and albuminous matter. Pure essential oil of the flower or "absolute" can be prepared by extracting the concrete with warm ethyl alcohol and subsequent removal of alcohol under vacuum.

CHOICE OF SOLVENT

(a) Solvent should be chemically nonreactive towards the essential oil being extracted otherwise the odour value of the product is likely to be altered.

(b) Solvent should have a low boiling point and high volatility. This is because complete removal of solvent from the product is most essential to avoid an objectionable off note due to the presence of residual solvent.

(c) Solvent should have a selective action with high solvent power for the desired product as compared to plant waxes, pigments and albuminous matter.

(d) Solvent should be reasonably cheap and readily available in pure state.

(e) Solvent should be immiscible with water.

Some of the commonly available solvents which meet the above requirements are acetone, petroleum ether or hexane, ethyl alcohol, dichloroethane and benzene. Some manufacturers are known to use a mixture of two solvents for some specific applications. The need for using pure solvent cannot be overemphasised. Even minute quantities of foul smelling impurities like sulphur compounds present in the solvent will ruin the aroma quality of the final product. Most of the solvents can be purified by fractionation over an efficient distillation column and using the middle cut for extraction. Treating the solvent with sulphuric acid prior to fractionation will remove most of the sulphur impurities.

SOLVENT LOSS

The extent of solvent loss in the process of extraction has a direct bearing on the economics of the operation. There are two main areas of solvent loss;

(a) Solvent occluded in the plant material in the extractor.

(b) Solvent loss occurring due to normal vaporization at all the solvent handling points.

Most of solvent occluded in the plant material after the last wash can be recovered by vaporizing it with live steam, injected into the extractor bottom, followed by condensation and separation from the immiscible condensed water. This arrangement can be seen in Figure 8. The second source of solvent loss is minimised by using leak tight extractors and storage tanks and leading all the vent lines to a suitable solvent trap. The solvent trap, also called a "Breather", can be a condenser with chilled brine circulation to condense back any escaping solvent from the vent lines. Use of activated carbon packed solvent traps, as shown in Figure 8, is also quite common. Trapped solvent is liberated from the activated carbon by passing steam and the bed is regenerated by passing hot air.

It may be added that extraction with volatile solvents is a technology intensive process and well trained operators are necessary to man such installations in view of the everpresent fire hazard. All necessary precautions for fire – safety must be scrupulously observed.

EXTRACTION WITH LIQUEFIED GASES

Extraction of natural flavours and essential oils from plant materials using liquefied gases like carbon dioxide as solvent is a recent development of great importance. Presence of solvent residues in the final product has always been a problem with the conventional solvent extraction process employing solvents like hexane or dichloroethane. Enhanced consumer concern for quality and safety of foods in developed nations has reflected in stringent government regulations on allowable residues in food flavours and spice oleoresins. Liquid carbondioxide near its critical point (73 kg/cm^2 Pressure & 31°C) has been found to be an efficient solvent for extracting a number of natural products like hops, coffee, chamomile flowers and a variety of fruits and vegetables. Being inert and non – toxic, carbon dioxide poses no problem of objectionable residues. The possibility of fire hazard with the use of conventional volatile solvents is totally eliminated when carbon dioxide is used.

The process essentially involves circulation of liquefied gas, near its critical point, through a high pressure extraction vessel. The solute is separated from the solvent gas by a change of pressure or by complete vaporization. The gas is recompressed for use again.

It has been shown that extracts obtained with supercritical carbon dioxide compare favourably with, and are often superior to, conventional solvent extracts.

A commercial scale plant has been set up at Bremen, West Germany, by M/s HAG – AG for decaffeination of coffee beans using liquid carbon dioxide. Extraction of hops using liquefied carbon dioxide has also been commercialised in Australia.

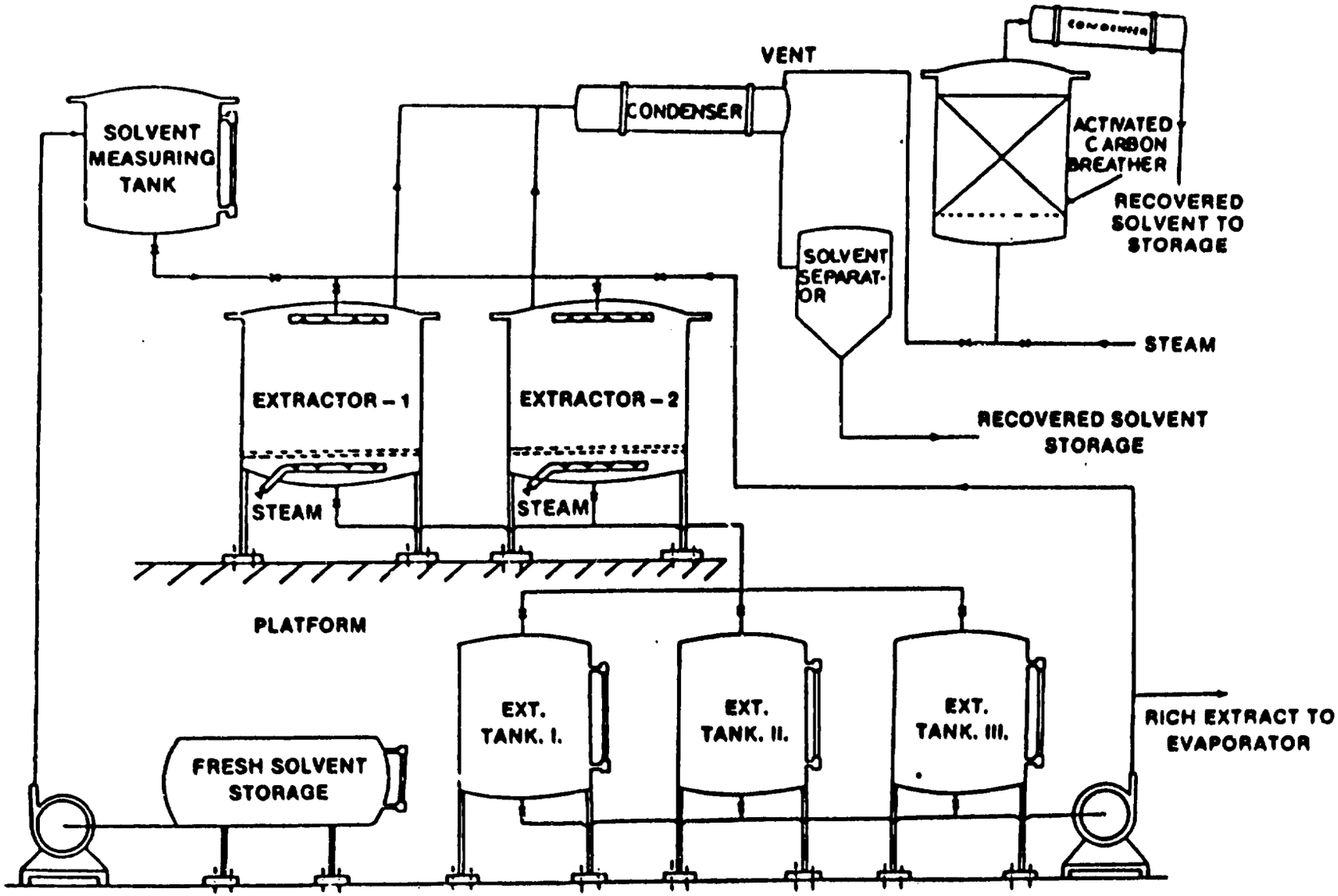


FIG. 8 SOLVENT EXTRACTION PLANT WITH BREATHER

FRACTIONATION OF ESSENTIAL OILS

Many of the essential oils as obtained in their natural state cannot be used directly for perfumery or medicinal purposes. For example in case of lemongrass oil it is only its constituent CITRAL which finds use as raw material for the preparation of Ionones and Vitamin – A. Similarly geraniol is isolated from the oil of palmarosa for perfumery applications. Needless to say, pure isolates of essential oils command much higher prices on account of their superior olfactory value as compared to essential oils.

The technique of fractional distillation is used to split the essential oil into its constituents. Chemical reactions are also employed for the preparation of pure isolates where fractional distillation is unable to achieve the desired results. In order to prevent heat damage to the products, fractional distillation is invariably carried out under vacuum. Figure 9 presents the essential features of the process. The essential oil is charged to the kettle known as reboiler and made to boil under vacuum by providing heat from a steam jacket and a steam coil. The vapours rise in a tall column which is packed with porous materials like ceramic or metal rings. Vapours are condensed in an overhead condensor. A special valve, mostly automatically operated, called reflux divider, sends part of the condensed oil back to column and the rest to the product receivers. By a careful manipulation of reflux ratio and column temperature, it is possible to separate the different constituents of essential oil which have different boiling points. Constituents having their boiling points very close to each other cannot be separated by the process of fractionation and chemical means have to be adopted in such cases.

Design and fabrication of systems for high vacuum fractionation is a specialised job.

TREATMENT OF CRUDE ESSENTIAL OILS

Essential oil as obtained from the oil separator is in crude form. It may have suspended impurities and appreciable moisture content. It might even contain some objectionable constituents which degrade its flavour quality. Presence of moisture and impurities adversely affect the keeping quality of oil and accelerate the polymerization and other undesirable reactions. Addition of a drying agent like Sodium Sulphate to the oil, standing the oil overnight followed by filtration will remove the moisture and free the oil of suspended impurities. Use of high speed centrifuge to clarify the essential oils is very common.

Essential oils are frequently rectified or redistilled to remove objectionable constituents. In order to keep the temperature of redistillation within permissible limits the process is carried out under vacuum or with the help of steam distillation.

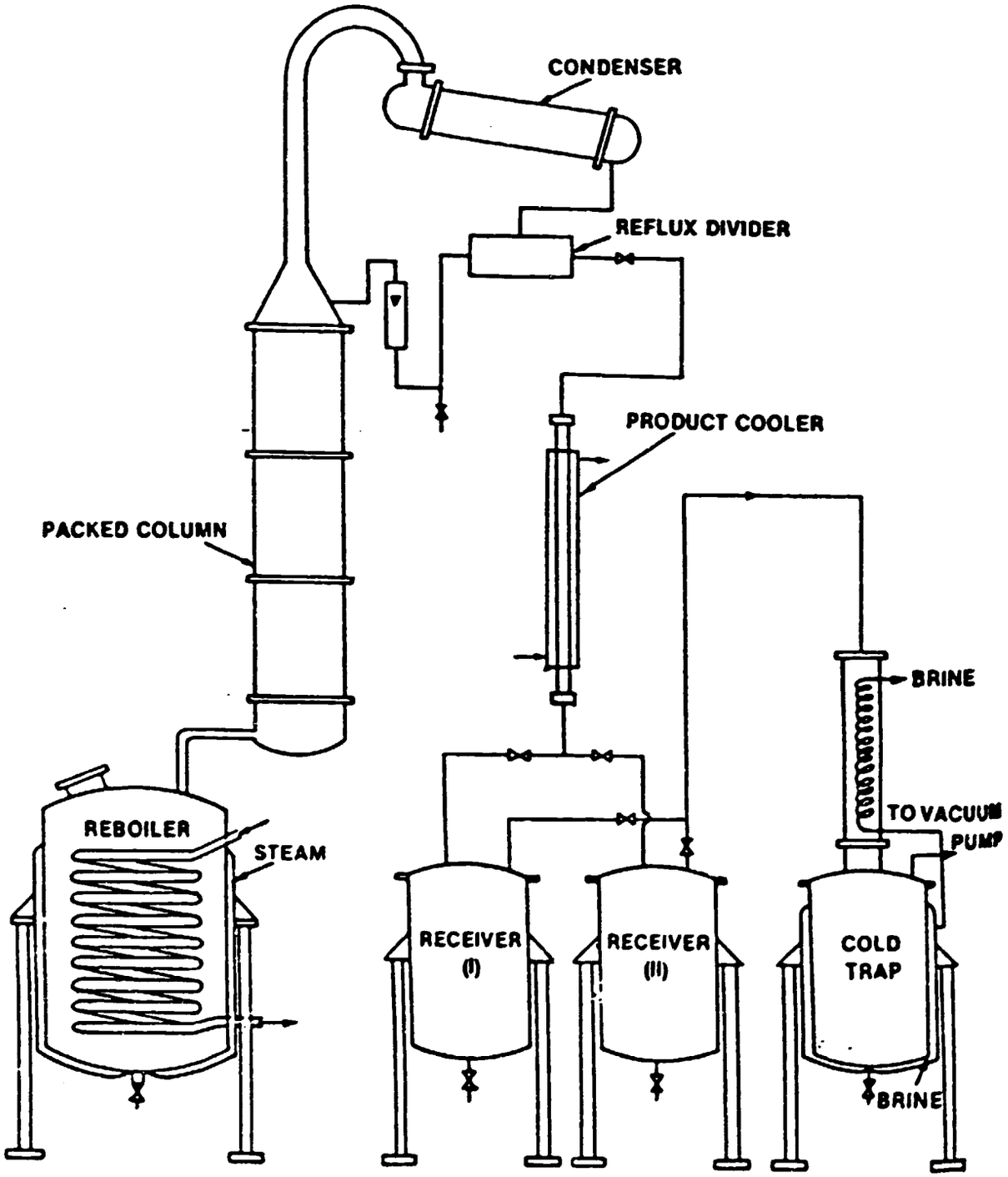


FIG. 9 FRACTIONATION COLUMN ASSEMBLY

ANNEXURE 25

PROJECT PROFILE FOR THE PRODUCTION OF FRAGRANCES AND FAVLOURS

1. Introduction:

Fragrances and flavours are an integral part of everday life. The application of Fragrances and Flavours has become so common today that often the exten of usage is not realised. Tryly speaking, the correct terms is industrial Fragrances or Perfumes and Industrial Flavours.

Technically speaking any mixture of two or more odouriferous substances would constitute a perfume or a flavour. Such a mixture is used in foods, is called a flavour and that used in any other application called a fragrance or a perfume.

The extent to which fragrances and flavours have permeated our lives can be guaged from the following lists:-

(a) Fragrance Applications

1) House Hold Products

Soaps & Detergents
Cleansers
Disinfectants
Polishes
Paints
Adhesives
Air Freshners & Deodourants
Joss Sticks
Insect Repellants

ii) Personal Products

Cosmetics
Toilet and Beauty Preparations
Perfumes & Toilet waters.

iii) Industrial Products

Dry Cleaning
Leather & Rubber Articles.
Artificial Leather.
Linoleum
Plastics
Printing Inks
Textiles

(b) Flavour Application

Confectionery
Chocolates
Ice Creams
Syrups
Cordials
Areated Waters
Liquers
Deserts & Puddings Sausages
Meat & Fish, Preserves
Sauces
Tobacco Products
Lipsticks
Mouthwashes and Toothpastes.

As is evident from these list, the articles that are commonly perfumes or flavoured are articles of daily necessity and their consumption is constantly increasing because of the rise in the standards of living of people at large.

Till the end of the last century perfumes and flavours were exclusively manufactured from natural ingredients such as Sandalwood Oil, Otto Rose, Jasmine Pommade, Saffron, Cinnamon, Fenugreek, Oilbanum, Myrrh, Calamus, Cassia, Spikenard, Vetiver, Musk, Benzoin etc. Towards the end of last centry, organic chemistry took a sudden leap forward and many chemicals such as Coumarin, Vanillin, Indole, Benzyl Acetate etc., which had either to been found only in natural materials, were successfully synthesised and in due course manufactured on a commercial scale. Today the proportion of usage of Natural and Synthetic materials is nearly 50:50.

As a general rule, the manufacture of Fragrances and Flavours represents an attempt on the part of man to duplicate nature for his own convenience and for the enhancement of his pleasure.

2. Marketing Feasibility & Scope

Ethiopia to-day represents a growing economy and a country where the standards of living are constantly increasing. Articles of daily use, such as those mentioned in the previous section are commonly used by the people.

The manufacture of many of these products is now being done in the country. Items such as Soaps, Detergents, some cosmetics and toiletteries, Joss sticks, Confectionery, Ice Creams, Chocolates, Areated Waters, Desserts, Puddings and Tobacco Products are now made in Ethiopia. However, as on today, there is not a single unit in the country making fragrances and flavours.

The inherent advantages of starting a Fragrance and Flavours Industry in Ethiopia may be listed as follows:-

1. There is no other unit in the country at the moment, hence the first unit to commence manufacture will acquire the gratest hold over the market and also earn the maximum goodwill.

2. Small customers which always constitute a sizeable proportion of the market can be easily serviced by a local unit. At present they are either unable to import because of small requirements of else they have to pay very high prices to local dealers for the material. As a result this segment of the economy is under a constant constraint.

3. A local unit can through its creative division design products exclusively for the local market in accordance with local tastes and needs.

4. Since European Companies generally work on the basis of a 200% margin on Raw Material costs, substantial savings can effected all round by import substituation. The import bill of the country can be brought down by nearly 60% as far as fragrance materials are concerned. The benefit of reduction in costs can be passed on to the consumer, thus stimulating the consumer goods industry.

5. Since Ethiopia is already a leading producer of spices and Essential Oils, the establishment of an integated unit making Essential Oils, Aromatic Chemicals, Fragrances and Flavours is a distinct possibility. Such a unit would already have the basic infra-structure and as such pre-operative costs would thus be negligible. In addition, the locally distilled essential oils could be consumed by such an industry leading to greater viability of the essential oils sector. Apart from this, a large number of raw materials are available from neighbouring countries such as India, Singapore, Malaysia and Indonesia.

6. Technical know-how regarding manufacture of end products could be diseminated to prospective entrepreneurs through the Applications Division of such a unit, thus spurring the growth an important segment of the industry. In due course of time, such a unit would form the nucleus for general growth of the Essential oils, Aromatic Chemicals, Fragrance and Flavours Industry in Ethiopia.

3. Variety of Products.

Although theoretically an infinite number of permutations and combinations are possible, given the large variety of Fragrance and Flavour Raw Materials now available, in practice both Fragrance and Flavours can be divided into a certain number classifications which form the fundamental building blocks all types of more complex fragrances and flavours.

Fragrances

The main categories are:-

1. Aldehydic
2. Floral
3. Chypre
4. Fougere
5. Oriental
6. Green
7. Citrus

Using one or more of these, nearly every type of fragrance can be created. Each of these types is characterised by the use of certain typical ingredients.

All fragrance creations are made with the end product and end use always being kept in mind. This is necessitated by the fact that perfumes be have differently in different media and as such to achieve a satisfactory

result, even within a given category, the same note may have to be created using different raw materials. For example Soaps are alkaline whereas shampoos are acidic. Furthermore, a fragrance does the job not only of giving the product in question a good smell, it also does the job of suppressing and disguiding the malodour of the ingredients making up the product..

Thus to sum up it may be said that Fragrances have to be by and large tailor made products, designed especially for a given end product and thus to achieve the greatest success it becomes necessary to service each customer individually.

Flavours:

The major categories are:-

1. Fruity
2. Vegetable
3. Spicy
4. Proteinaceous
5. Fatty
6. Emphyreumatic
7. Fermented

What has been said above regarding fragrances is equally true of flavours and thus similarly the successful commercial applications of flavours entails the production of custom made products.

4. Raw Materials.

The raw materials used in fragrances and flavours may be divided into the following categories:-

i) Natural Products

Absolutes
Balsams
Concretes
Essential Oils
Extracts
Gum & Gum Resins
Oleoresins
Resins & Resinoids
Spices
Tinctures

ii)Synthetic & Semi Synthetic Products

i) Aroma Chemicals (Odouriferous Substances)
ii) Solvents (non-odouriferous Substances).

Addition of fragrance and flavour raw materials to food stuffs, Cosmetics and cleaning and disinfection products requires that no health hazards arise from the concertrations used. Increasing knowledge of possible risks has provided toxicological data on many substances and mixtures. Monographs on single fragrance components and essential oils are

published by 'Research Institute for Fragrance Materials' (RIFM). Based on these and other data the 'International Fragrance Association'(IFRA) publishes industry guidelines for limiting or prohibiting the use of certain fragrance materials. Similarly, the 'International Organisation of the Flavour Industry' (IOFI) publishes lists of naturally occurring and nature idential flavour components, which may be used upto certain concentrations, as well as of artificial flavour substances, which are considered harmless.

5. Processing Method, Equipment and Quality Control

The heart of a fragrance or a flavour is the 'FORMULATION'. A formulation is prepared by either studying and analysing the fragrance/flavour to be duplicated or by imagining within the mind a fantasy of odour and smells in much the same way as a musician would imagine a symphony and put it down on paper as a musical score. In exactly the same way a perfumer percieves a fragrance or a flavour as a harmonious blend of various odours and put it down on paper as a formulation.

Thus to begin with, one must have 'Formulations' from which the fragrances and flavours must be produced. The process of blending fragrances and flavours may be systematically represented by the following steps:-

1. Establishment of a blending laboratory which contains all the available raw materials and facilities to weigh the same in small quantities.

2. Finalisation of the 'Formulations' to be used for the manufacture of fragrances and flavours by trying out various combinations of raw materials and selecting those found to be most suitable.

3. Procurement of all the raw materials occuring in the final formulations.

4. Establishment of the blending unit in neat and clean premises which are fully protected from dust, pests and flies and/or any other type of contamination. Provision within the premises of weighing, blending and packaging equipment.

The actual process of manufacture consists of mixing the ingredients of a formula together in their proper proportions; mixing them well and then allowing the blended product to mature for a certian amount of time. After maturity, the blended product is evaluated against the standard sample and if found to be acceptable is packed and despatched to the customer. Generally the following equipment is sufficient :-

1. Accurate weighing balances.
2. Efficient mixers/blenders.
3. Packaging Machines.
4. Heating Equipment to melt solid and resinous materials and accelerate maturity if necessary.

Quality Control :

Quality control of fragrance and flavour substances as well as products derived from them, includes comparison of sensors and analytical data with standards and specifications.

In addition to organoleptic evaluation, analytical determination of identity and purity is used to establish the acceptability of fragrance and flavour materials. Single fragrance and flavour compounds are characterised by generally accepted physical constants such as density, refractive Index, Optical rotation and melting point. Determination of content by chemical data such as ester value and Carbonyl content are supplemented by spectroscopic techniques such as UV, IR & NMR, and by chromatographic procedures such as GC and HPLC.

Standardisation of complex flavour and fragrance materials such as essential oils are more difficult. In addition to organoleptic and physical properties, the content of certain typical components is determined. In addition modern chromatographic and spectroscopic analytical techniques are applied.

6. Technical Feasibility :

Full Technical know-how can be made available by the expert. In addition to the know-how required for start up, training to the requisite number of personnel can also be organised.

7. Project Parameters for a Typical Installation.

i) Production Capacity:

Fragrances	:	20 tonnes per year
Flavours	:	20 tonnes per year

ii) Factory Accomodation

Production Plant	:	15m x 10m
On site storage of Raw Materials	:	15m x 10m.
Packaging & Despatch Division	:	15 x 10m.

iii) Machinery & Equipment

Weighing Balances
Mixers Blenders
Packaging Machines
Heating Equipment
Total cost (Including Installation): US $ 50,000.00

iv) Raw Materials

For Fragrances & Flavours (Aroma Chemicals, Essential Oils, Resinoids and Solvents)	:	41 tonnes for 40 tonnes of finished products.

v) Utilities :

Power Requirement	:	25 KVA
Estimated power consumption per year	:	5000 KW-Hr.
Water	:	For Personal Hygiene, drinking and small services only.

vi) Employment:

Unskilled Workers	:	3
Semi Skilled Workers	:	4
Skilled Worker	:	1
Supervisor	:	1
Office Staff	:	2
Total	:	11

vii) Return on Investment
Approximately 85%

ANNEXURE 26

AGRONOMICAL PRACTICES FOR CULTIVATION OF ESSENTIAL OIL CROPS

OILS FROM *CYMBOPOGON* SPECIES

The genus *Cymbopogon* comprises about 140 species. Some of the species yield essential oils which as such or their pure isolates are used in perfumery. The infusion of several species of *Cymbopogon* are used for treatment of a number of human diseases as gout, cough, cold, etc. Some species are used as inferior fodder, whereas a few are ornamental ones. Among the essential-oil-yielding *Cymbopogon* species, following are considered as economically important for production of essential oils:

I. *Cymbopogon winterianus* - yields oil of citronella Java.

II. *Cymbopogon citratus* and *C. flexuosus* - yield oil of lemongrass.

III. *Cymbopogon martinii* var. *motia* - yields oil of palmarosa.

Cymbopogon winterianus (Java citronella) Close-up of a single plant

Field view of *Cymbopogon winterianus* (Java citronella)

OIL OF CITRONELLA

INTRODUCTION

Oil of citronella is one of the important essential oils obtained from different species of *Cymbopogon*. The oil is used extensively as a source of important perfumery chemicals like citronellal, citronellol and geraniol, which find extensive use in soap, perfumery, cosmetic and flavouring industries throughout the world.

Citronella oil is classified in trade into two types - Ceylon citronella oil, obtained from *Cymbopogon nardus* Rendle, is the inferior type, while Java type citronella oil obtained from *Cymbopogon winterianus* Jowitt, is considered superior. Both of these have probably originated from *Mana Grass* of Ceylon, which according to Finnemore (1962) occurs today in two wild forms - *Cymbopogon nardus* var. *linnaei* (typicus) and *C. nardus* var. *confertiflorus*. Both of these forms are not known to be used for distillation to any appreciable extent. The Java citronella, which is called *'Mana Pangeri'* in Ceylon, is the result of selection from the Ceylon citronella and the name *Cymbopogon winterianus* is given to this selected variety to commemorate one Mr. Winter - an important citronella oil distiller of Ceylon, who first cultivated and distilled *Mana Pangeri* type of citronella in Ceylon.

At present, the world production of citronella oil is approximately 7000 tonnes, the bulk of which is produced in Taiwan, Guatemala, Honduras, Indonesia, Brazil, China, Ceylon, India, Argentina, Equador, Madagascar, Mexico and West Indies.

BOTANY

A tufted aromatic perennial herb with fibrous roots; culms stout, erect, over 2 m tall, terete, smooth and shining, leafy, glabrou. at the nodes; leaf blades linear, gradually tapering to a long membranous acuminate tip, up to 1 m long, 1.5 cm wide, drooping at 2/3 length, coriacious, green or yellow-green above, glaucous below, smooth and glabrous, sharply scabrid, serrate along the margins; sheaths smooth and glabrous, striate, yellow or purplish red, those of the culms tight clasping, shorter than internodes, those at the base very short, loose, slipping from the culms; ligule scarious, often lacerate, ciliate; stem tall, suberect, sterile shoot cream coloured in sections. Inflorescence, a very large decompound panicle, spreading loose, over 30 cm long, erect, finally drooping, consisting of a branched and rebranched axis, giving rise to branches of the third and fourth degree which finally end in racemes pairs, supported by proper sheaths; spathes 12 mm long, narrow, many nerved, dull reddish, membranous on the margins; racemes 20 mm long, one sessile or short, the other longer-pedicelled with the two lower spikelets, homogamous, male or neuter, the pedicel not swollen, the remaining pairs in both racemes heterogamous, divergent but not epinastically deflexed; joints 3 mm long, slender, terminating into a toothed cup, pedicels shorter, otherwise similar; sessile hermaphrodite spikelets 3.5-5.5 mm long, oblong acute; lower glume convex or flat on the back, 2-keeled, with three intracranial nerves, 3.5-5.5 mm long, 1-1.2 mm wide, smooth and glabrous, save on the narrow wings at the tip which are scabrids; upper glume navicular, smooth and glabrous, keeled in the upper half, rounded on the dorsal surface, 3-nerved; lower floret empty, lemma hyaline, lanceolate, scale 3 mm long, ciliate on the margins above, palea not seen; upper floret, lemma narrow, 3 mm long, hyaline, divided into very short ciliate lobes; palea absent; awn 3 mm long, styles 2, stigma plumose, stamens 3, anthers 1 mm long; pedicelled spikelets 3.5 mm long, lanceolate-acute; lower glume slightly keeled at the apex, rounded on the sides, about 9-nerved, scabrid on the keels at the apex; upper glume equal in size, 3-nerved, smooth and glabrous, ciliate on the margins near the apex; lower and upper florets represented by a single hyaline scale 3 mm long encircling three stamens, anthers 2 mm long, lodicules 2, truncatecuneate. Plants often flowering, cultivated in Java.

SOIL AND CLIMATE

Citronella flourishes best under tropical and subtropical climate. It needs abundant moisture and sunshine for good growth. Rainfall between 200-250 cm, well spread over the year, is ideal for the crop. In areas where rainfall is scanty, plant can be grown with supplemented irrigations.

The plant grows under varying soil conditions, but the sandy loam soil with abundant organic matter is the most suitable. Heavy clay soils and sandy soils do not support good growth of the plant. The plant grows well under wide range of pH-acidic (5.8) to slightly alkaline (8.0). However, pH around 6.0 is optimum for this crop.

Although the plant grows well at the altitudes between 1000 m and 1500 m but an altitude of 180-120 m is the optimum.

PREPARATION OF LAND

The land is ploughed and disced so as to get fine tilth. In areas where soil insects are a problem endrin or heptachlor (5% dust) at the rate of 50 kg per ha should be applied at the time of last harrowing to protect against soil-borne insect pests. The field should have enough moisture at the time of planting. All the grass stubles and weeds should be removed before planting.

PROPAGATION

Java citronella flowers, but viable seeds are not formed because of irregularities in meiosis and, therefore, the species are propagated vegetatively. This is done by splitting the clumps into slips. Each slip contains 1-3 tillers and is the unit of propagation. On planting these slips establish themselves as plants or bushes. Fibrous roots and leaves should be trimmed off the slips before planting.

Although the plantation of Java citronella can be started anytime during the year, rainy months are ideal for planting. Healthy, vigorously growing and young bushes should be selected for supplying the slips. If the planting is delayed, the slips may partially dry up which will result in poor plant population. The slips are planted vertically, about 10 cm deep. The slips should be planted at a distance of 60 cm in rows, spaced 60 cm apart. However, in areas where the soil is fertile and the climatic conditions support luxurious growth, a spacing of 90 x 90 cm may be kept.

Plants are sensitive to even temporary waterlogging, which adversely affects the growth of the plant. It is, therefore, advisable to plant citronella on ridges to avoid waterlogging.

The field should be irrigated immediately after planting if it does not rain within next 24 hours.

FERTILIZER APPLICATION

Fertilizer requirement depends upon the fertility of the soil. However, Java citronella generally requires high dose of nitrogen for good growth. It needs 80-120 kg N/ha per year. For the soils with high fertility level, the dose may be reduced. The recommended annual doses of P_2O_5 and K_2O are 40 kg/ha each. It is beneficial to apply N in 4 equally split doses, the first about a month after planting and then after each harvest, at an interval of about three months.

In areas where the plant grows throughout the year, higher fertilizer dose is needed. In poor soils, 200 kg N and 80 kg P_2O_5 per ha should be applied. Nitrogen is applied in 5-6 split doses.

INTERCULTURE AND WEED CONTROL

The citronella plantation should be kept weed-free. When the plants have established themselves and formed bushes, the problem is not so severe because of the very nature of growth of the bushes. However, in the newly established plantations and after each harvest, the weeds grow in the inter-row spaces and weeding becomes essential. This can be accomplished by running cultivator in between the rows. Recent work has shown that weeds can be controlled through the application of oxyflureofen, diuron and simazine at the rate of 0.5, 1.5 and 2.0 kg ai/ha, respectively. Exhausted grass applied as mulch @ 3 to 5 tonnes/ha suppress weed growth and is equally effective.

IRRIGATION

The plant requires adequate moisture for good growth and yield of leaves. In the areas where annual rainfall is about 200-250 cm, well distributed over the year and the humidity is high, supplemental irrigation is not necessary. In the drier months, however, the irrigation may be provided and this increases the yield.

HARVESTING

Although all the plant parts contain oil, leaves contain the maximum amount of the oil. Furthermore, the oil from other parts is of inferior quality. Therefore, it is desirable to harvest only the leaves. The number of harvests, which can be taken during a year, depends upon the growth of

the plants. Under favourable conditions, up to 4 harvests can be obtained in a year. The leaves are ready for first harvest, about 6 months after planting. The second and subsequent harvests can be taken thereafter 2½-3 months' interval. Harvesting too soon and too late affects the quality of oil adversely. The delay causes the leaves to dry up resulting in decrease in oil yield. While harvesting, only the leaf blade should be cut and the sheath should be left. This is because the sheath contains only little and poor quality oil.

The same schedule of harvesting should be followed during second and subsequent years. Java citronella plantations remain productive for 5-6 years but the yield of leaves and oil is maximum during second and third years, after which it starts decreasing. It is recommended that the plantation should be uprooted after 3-4 years and rotated with some small legume crops.

DISEASES AND PESTS

While very few pests have been observed to affect the crop, citronella plantations have been affected by a serious leaf blight disease. The leaf blight is caused by *Curvularia andropogonis* (Zimm.) Boedijn. As a result of this infection, there is considerable decrease in leaf and oil production. The disease can be controlled by prophylactic spraying of any of the Dithiocarbamates, namely, mancozeb and zinab at an interval of 10-15 days during the growing period.

Another fungus *Collectotrichum graminicola* (Ces.) Wilson affects the crop. This disease can also be controlled by application of the above fungicides.

DISTILLATION

The grass is steam-distilled for better recovery of oil and economical purposes.

Growers cultivating smaller areas can make use of properly designed direct-fired stills, in case they are not able to invest in the purchase of a boiler. However, distillation in such direct-fire still takes a little more time and the quality of the oil is also inferior.

Java citronella oil should preferably be stored in glass/aluminium containers.

OIL CONTENT AND OIL YIELD

The oil content of the leaves is affected by various factors, such as soil, climate, age of plantation and method and efficiency of distillation. On an average, however, the oil content is about 1% on the basis of fresh weight of leaves.

Depending upon the nature of growth, the yield of fresh leaves is about 15-20 tonnes/ha in the first year and 20-25 tonnes/ha in the second as well as in the third year, after which the yield declines.

The yield of oil during the first year is about 75 to 100 kg/ha and 150 kg/ha during second and third years. A yield of 200-250 kg oil/ha can be obtained under very favourable conditions.

CHEMICAL CONSTITUENTS AND USES

As mentioned earlier, two types of citronella oil are known commercially: Ceylon type and Java type. The oils differ chemically. The constituents of Java type oil are:

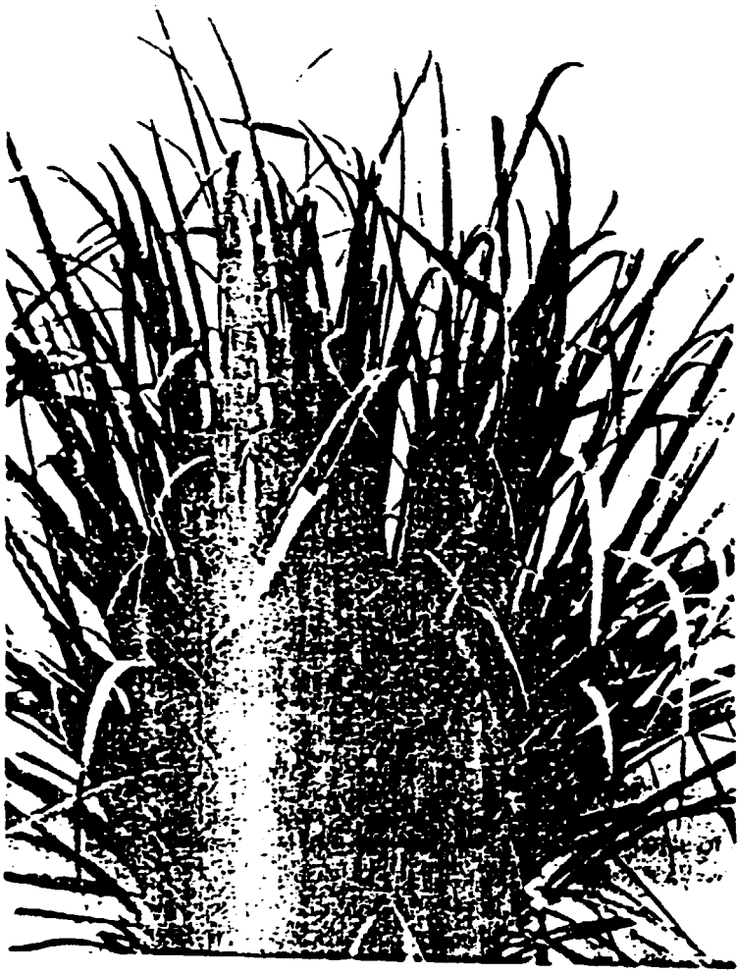
Major constituents

Citronellal 32-45%
Geraniol 12-18%
Citronellol 11-15%
Geranyl acetate 3-8%
Citronellyl acetate 2-4%
Limonene 2-5%
Elemeol and other sesquiterpene alcohols 2-5%
β-Elemene and γ-Cadinene 2-5%

Minor constituents

Bisabolene
Borneol
Bourbonene
Caryophyllene
α -Celanene
Calamenene
Citron ethyl butyrate
Cubebene
Elemol
Eugenol
Farnesol
Geraniol
Geranyl acetate
Isopulegol
Linalool
Linalyl acetate
Methyl eugenol
Methyl heptenone
Myrcene
Neral
Nerol
α -Pinene
Terpinen-4-ol

The oil is used extensively in perfumery. Soaps, soapflakes, detergents, household cleansers, technical products, insecticides, etc., are often perfumed with this oil. The oil is also a source of certain important chemicals. Citronellal has only limited applications as such in perfumery and is occasionally used in traces in flavour compositions. However, citronellal is a starting material for further derivatives. Hydroxycitronellal can be prepared from citronellal and it finds its way into floral fragrance and a great many non-floral ones. For soap perfumes, a slightly more rough grade is used. High grade is used in flavour compositions. Furthermore, l-menthol is made from hydroxycitronellal. Geraniol ex-citronella is not a particularly important derivative as most commercially used geraniol is obtained from pinene. However from geraniol ex-citronella, one can obtain citronellol. Citronellol is used in many perfumery blends of the soap and cosmetic industries when rosacious notes are required. Citronellol esters, e.g., the formate and acetate are also used in wide range of fragrances. Citronellol can also be prepared from citronellal.



Cymbopogon flexuosus
(Lemongrass)

Close-up of a single plant

Field view of *Cymbopogon flexuosus* (Lemongrass)

OIL OF PALMAROSA

INTRODUCTION

Oil of palmarosa is obtained from floral shoots and aboveground parts of *motia* variety of *Cymbopogon martinii* Stapf. This variety yields an oil of high geraniol content (75-90%). Another variety, *sofia* yields oil of lower geraniol content which is known as gingergrass oil. The oil is of inferior grade and fetches much less price than the palmarosa oil.

BOTANY

Palmarosa is an aromatic perennial grass. It attains a height up to 300 cm. The aerial parts die in the winter. Being very susceptible to frost, its leaves and shoots may dry up even in November where there is early frost, but usually withering starts in December, and by the end of January the plant dries up completely.

Leaves linear-lanceolate to lanceolate, cordate or amplexicaul, 8-50 cm long, 1-3 cm broad, finely caudate; panicles 10-30 cm long, turning reddish, often very bright, when mature; glumes 3.3-4 mm long, awns 11.4-14 mm long; lower glume of fertile spikelets deeply channelled: Channel of glume in lower half, very narrow, corresponding to a rib on the inner side, lowest pedicel of sessile racemes slightly swollen and connate to the base of the rachis.

SOIL AND CLIMATE

A well-drained loamy soil having irrigation facilities and receiving rainfall of about 150 cm annually is an ideal condition for cultivation of palmarosa. It also grows well in well-drained clay soil, free from water-logging. If the soil is not well-drained or if after heavy irrigation, water remains standing in the hot weather, the growth of the grass is badly affected. Areas which are affected by severe frost are not suitable as the frost kills the grass and reduces the oil content.

PREPARATION OF FIELD

The field is prepared before the onset of rainy-season. It is ploughed and harrowed so as to give a fine tilth. All the stubble and roots of weeds are removed.

PROPAGATION

Palmarosa is propagated through seeds. A limited extent of propagation can be done through slips, but is not suitable for commercial planting.

TRANSPLANTING NURSERY-RAISED SEEDLINGS

Nursery beds are prepared in May. Raised beds are preferable as the seeds are not washed off by irrigation. Liberal amount of farmyard manure should be used in the seedbed.

As the seeds are small and light, they are mixed with fine soil for even distribution and ease in sowing. They are sown in lines, 15-20 cm apart. Seeds should not be sown densely as this will lead to crowding of seedlings resulting in poor growth of the plants. About 2.5 kg seeds are adequate to give seedlings for planting an hectare.

The beds are watered lightly and regularly. Germination starts within two weeks. Later on, a weak solution, i.e., 0.2-0.5% of urea may be given for good growth. In about 3-4 weeks, seedlings are ready for transplanting.

The seedlings are transplanted in the prepared fields as soon as the rainy season sets in. They can be transplanted even earlier, if the weather is not very warm and irrigation is available.

Healthy and established seedlings, which are 15 cm high, are carefully removed from the nursery and are planted in rows, 60 cm apart with plants spaced at same distance. In fertile areas, spacing should be increased.

BY ROOT-CUTTING

Plants giving good yield and high quality oil are to be used. In this way, it is possible to raise plantations yielding high quality oil, which is not possible when the plantation is raised from seeds as the seeds give rise to many morphologically indistinguishable different types of plants. However, the rate of establishment of rooted slips is very poor as compared to nursery transplants. Slips are planted during the rainy season. This method can be only recommended for serving experimental plantations as it is not economical for commercial farming.

Close-up of *Cymbopogon martinii* var. *motia* (Palmarosa)

FERTILIZER APPLICATION

As the grass is perennial, it is necessary to replenish the soil. In rich soils, manuring may not be required for the first two years. By manuring rich soils, the vegetative growth is increased and oil content is reduced. In deficient soils, a mixture consisting of 20 kg N, 50 kg P_2O_5 and 40 kg K_2O per ha is used as basal dose at the time of planting. About 60 kg N/ha is applied in three split doses during the growing season. The mixture of NPK should be repeated at the time of appearance of fresh leaves each year.

WEEDING AND INTERCULTURES

Odour is an important factor of the oil quality and it is essential to keep the fields clean of other growing plants, particularly those which impart their own odour. Therefore, the plantation should be kept free from weeds by regular weeding and hoeing. Particular care is required in the initial stage of growth so that weeds do not provide severe competition to the crop. Recent work has shown that weeds can be controlled through the application of oxyfluroefen, diuron and simazine at the rate of 0.5, 1.5 and 2.0 kg ai/ha, respectively. Distillation waste, when applied as much @ 3 to 5 tonnes/ha suppress weed growth and is equally effective.

IRRIGATION

Requirements of irrigation depend upon the climatic conditions. The grass requires irrigation after about ten days during the growing season. With an ample supply of water, growth is luxuriant, but if drought prevails, the growth is arrested, leaves wither and the oil content is reduced. However, in areas having well distributed rainfall, no irrigation is required.

HARVESTING

The essential oil is distributed in all the parts of the grass, viz., flower heads, leaves and stems, the flower heads containing the major portion. Usually the whole grass is cut at a height of 5-8 cm from the ground level for distillation. The maximum yield of oil is obtained when the plant is at full flowering stage.

The number of harvests depends upon the climatic conditions of the place of cultivation. During the first year, usually one crop is obtained during October-November, whereas 2-3 crops are obtained in the subsequent years.

Palmarosa plantation remains productive for about 8 years. However, the yield of grass and oil starts decreasing from the fourth year onwards. It is, therefore, recommended that the plantation is kept only for 4 years.

DISTILLATION

Oil of palmarosa is obtained by hydrodistillation as well as by steam distillation. The former process is primitive and quality of oil as well as oil recovery is poor. To get maximum yield of good quality oil, it is advisable to use steam distillation.

For economical production of the oil, it is advisable that the harvested material is allowed to wilt for a short time.

From quality point of view, the grass should be distilled as fresh as possible. Oil obtained from dry or fermented grass is of inferior quality. The distillation unit should be clean, rust-free and free of any other odour.

The oil should be free from sediments, suspended matter and moisture before storing it. The containers should be clean and rust-free.

OIL CONTENT AND YIELD

The content and yield of the oil depend upon many factors, such as climatic conditions of the place of cultivation, time of harvesting, maturity of the grass, nature of material being distilled, i.e., fresh material, wilted material, method of distillation, etc.

All parts of the plant contain the essential oil, the maximum oil being present in flowers, the stalks containing negligible quantity. On an average, the oil content in the various parts of the plant are:

Whole plant	0.10 to 0.40%
Stalks	0.01 to 0.03%
Flowering tops	0.45 to 0.52%
Leaves	0.16 to 0.25%

The yield of oil is low in the first year. It increases with the age of the plantation. From economic point of view, it is advisable to keep the plantation for four years. Yield for the first 4 years is as under:

1st year	20 kg/ha
2nd year	60 kg/ha
3rd year	70 kg/ha
4th year	70 kg/ha

CHEMICAL CONSTITUENTS AND USES

Oil of palmarosa chiefly contains 75.0-95% of alcohols calculated as geraniol. Other constituents reported are:

Citronellol	Linalool
p-Cymene	Limonene
Farnesene	Methylheptenone
Farnesol	Nonanol
Geranyl acetate	α-Terpineol
β-Humulene	β-Terpineol

Oil of palmarosa is used in perfumery, particularly for flavouring tobacco and for blending of soaps due to the lasting rose-note it imparts to the blend. In soap perfumes, it has a special importance by virtue of geraniol being stable in contact with alkali. It also serves as a source of a very high grade geraniol.

Geraniol is highly valued as a perfume and as a starting material for a large number of synthetic aroma chemicals, viz., geranyl esters which have a permanent rose-like odour.

OIL OF LEMONGRASS

INTRODUCTION

The trade name Lemongrass is applied to two species of *Cymbopogon*: *Cymbopogon flexuosus* (Steud.) Wats and *C. citratus* Stapf., called the East Indian Lemongrass and the West Indian Lemongrass, respectively. The common name lemongrass has been given because of typical strong lemon-like odour of the plant due to high citral content (75-90%) of the essential oil present in the leaves.

Lemongrass oil is one of the most important essential oils produced in the world. The oil is produced mostly because of its high citral content, which is used as a basic raw material for synthesis of ß-ionones used for synthesis of a number of aromatic useful compounds and Vitamin-A. Citral itself is used as a perfumery for various grades of soaps and cosmetics.

Among the two species cultivated, *C. flexuosus* also known as Malabar or Cochin Grass, is indigenous to India, whereas *C. citratus* is cultivated in West Indies, Guatemala, Brazil, etc. The oil of *C. citratus* is considered inferior as it contains slightly less citral (60-75%), whereas oil from *C. flexuosus* contains more citral (75-90%). The West Indian oil is usually less soluble in 70% alcohol than the East Indian. The lower solubility of the West Indian oil is due to the presence of myrcene, an olefic terpene in the foreruns; this, on exposure to air and light, readily polymerizes.

The term 'West Indian' is a misnomer, as this oil is now produced not only in the West Indian Islands and in the Central American countries, but in South America, in the Comoro Islands, Madagascar and China.

BOTANY

C. flexuosus

Two types of East Indian Lemongrass are known: the so-called 'red grass', locally known as *'Choomanna poolu'*, the true *C. flexuosus*. The colour of stem is reddish. The leaves yield the normal East Indian Lemongrass Oil, containing 75% or more of aldehydes, chiefly citral and exhibiting good solubility. The bulk of Indian Lemongrass is produced from the red grass. The so-called 'white grass', locally known as *'Wella poolu'* has been identified as *C. flexuosus* var. *albescens*. The colour of the stem is white. The oil obtained from the plant has very low aldehyde content and poor solubility.

C. flexuosus var. *flexuosus*: Aromatic grass; 210-315 cm tall; leaves linear, lanceolate, 125 × 1.7 cm; panicle very large, drooping, lax, greyish or greyish green, rarely with a tinge of purple, decompound, with the raceme pairs in dense masses, spreading, 100-135 cm tall, slightly hairy, low glumes of the sessile spikelets 3-4, rarely 4.5 mm long, 1 mm wide, with 1-3 definite or obscure intracarinal nerves, shallowly concave with one or two depressions.

SOIL AND CLIMATE

Lemongrass requires a warm and humid climate with plenty of sunshine and rainfall, ranging from 250 cm to 300 cm, uniformly distributed over the year. It is hardy plant and resistant to drought.

High temperature and sunshine are conducive to the development of oil in the plant. In hilly places receiving heavy rainfall, the plant grows luxuriantly and is harvested more frequently but the oil and citral contents are less as compared to the plants growing in the regions receiving less rainfall.

It grows well at altitudes between 100 and 1200 m, generally on poor soils along with hill slopes, but flourishes on a wide variety of soils ranging from rich loam to poor laterite. The grass grows best on well-drained sandy-loam soil; it even thrives on light-sandy soils, provided they are well

manured. Plants from such a sandy soil yield relatively more oil with higher citral content than plants from very fertile soil.

PROPAGATION

The plants are propagated both from seeds and rooted slips in case of *C. flexuosus*, whereas in case of *C. citratus*, it is propagated through rooted slips. However, it is better to propagate the plant by vegetative methods from selected clones, as seed propagation leads to considerable genetic heterogeneity resulting in deterioration of yield and oil quality.

Collection of seeds : The crop flowers during November-December and seeds are collected during January-February. For collection of seeds, the plants are left without harvest as yield of seeds from plants subjected to regular harvest are less. On an average, a healthy plant gives about 100-200 g of seeds. At the time of seed collection, the whole inflorescence is cut and spread in the sun for drying for 2-3 days. They are then thrashed and seeds are again dried in the sun. They are finally stored in gunny bags. The seeds lose their viability if stored for a longer period.

Preparation of nursery : The plant is cultivated preferably as a transplanted crop as transplanting has been found to be superior to direct sowing of seeds in respect of the various economically important characters such as grass yield, oil content and citral percentage. The seeds are sown by hand in a well-prepared nursery at the onset of the monsoon during April-Mayland are covered with a thin layer of soil. The nursery is watered in case rain fails. About 10 kg of seeds are adequate to raise seedlings for planting an hectare. Seeds germinate in 5-6 days. Seedlings are ready for transplanting when about 60 days old.

Transplantation : Seedlings are planted at a distance of 45-60 cm in rows, 60-70 cm apart. It is better to plant on ridges in areas receiving high rainfall.

PROPAGATION BY ROOT DIVISIONS

Tops of clumps are cut off within 15 cm of the root. The latter is divided into segments and the lower brown sheath is removed to expose young roots. One or two segments are placed into each hole, about 15 cm deep. Deeper planting is dangerous as the plants may develop root rot during the rainy season. Each segment is transplanted firmly into the ground. This is done at the beginning of the rainy season.

Spacing of the segments depends upon the fertility of the soil and climatic conditions of place of cultivation. Placing the segments 60 cm apart in rows, about 90 cm apart is reasonable. Closely spaced plants give more grass than more wide-spaced ones but increase in oil is not as much as increase in the grass yield. The citral content of the oil from closely spaced plants is also slightly lower.

FERTILIZER APPLICATION

Lemongrass is a soil-exhausting crop. It is preferable to use spent lemongrass in the form of compost at the rate of about 10 tonnes per ha and wood ash at the rate of about 2 tonnes/ha. It supplies sufficient amount of nitrogen and potash which are the most important growth factors in the crop. The use of artificial fertilizers also give encouraging results. It is recommended to supply 30 kg P_2O_5, 30 kg K_2O and 30 kg nitrogen per ha as basal dose at the time of planting. Nitrogen (60 kg) can be applied as top-dressing in 3-4 split-doses during the growing season.

WEEDING AND INTERCULTURE

Weeding and hoeing are very important as they affect the yield and quality of oil. Generally, 2-3 weedings are necessary during the year. Earthing up should also be done at least once in a year. During the winter, the grass is usually burnt to fertilize the soil and to strengthen the plants. In row-planted crop, interculturing can be done by a tractor-drawn cultivator or hand-hoe. Weeds can also be controlled through the application of oxyflureofen, diuron and simazine at the rate of 0.5, 1.5 and 2.0 kg ai/ha, respectively. Distillation waste when applied@3 to 5 tonnes/ha suppress weed growth and is equally effective.

IRRIGATION

In areas receiving well distributed rainfall, no irrigation is required. However, lemongrass has a high water requirement and frequent irrigation is essential for getting optimum yield in those areas where rainfall is not well distributed.

HARVESTING

The time of harvesting affects the yield and quality of the oil. Young and tender grass, harvested in the early season, gives an oil which is low in aldehyde content (60-70%) and of poor solubility. Later, the aldehyde content of the oil increases to 75% and more. The yield of oil also increases. In general, the yield of oil is lower during rainy season as compared to dry months.

The first harvest is generally possible after 3 months of transplanting is case of *C. flexuosus* and after 6 months of planting of *C. citratus*. Subsequent harvests take place at intervals of 40-50 days depending upon the fertility of the soil and seasonal factors. Under normal conditions, three harvests are possible during the first year and four in subsequent years. Harvesting is done with the help of sickles, the plant being cut close to their bases about 10 cm above ground level.

DRYING

The grass is either distilled fresh or allowed to wilt for 24 hours. Wilting reduces the moisture content and allows larger quantity of grass to be packed into the still, thus economising the fuel use.

PESTS AND DISEASES

Several pests and diseases have been found to affect lemongrass. The most important one is a species of *Chilotrea* infecting lemongrass. The caterpillar is white in colour with a black head and black spots on the body. It bores into the stem and remains there feeding on the shoot. It is usually found at the bottom of the stem. As the grass is cut a few centimetres above the ground, the caterpillar, which is lodged lower down, is not affected.

The first symptom of the attack is the drying up of the central leaf. Subsequently, the whole shoot dies, resulting in a significant reduction in the yield of the grass.

Control measures are: (i) The dry stubbles are set on fire during the off season in summer. The caterpillars lurking inside the stubbles are thus destroyed. (ii) The affected shoots are pulled out and destroyed. (iii) When attacks are serious, a spray of oxydemeton-methyl is used. Instructions for spray, etc. should be followed as prescribed by the manufacturer.

Tolyposporium christensenni causes a long smut of lemongrass. All the flowers in the inflorescence are transformed into long, slender, tubular to conical cream-coloured sori. These sori flake off at maturity, starting from the tip and hang in shreds. The sporeballs are arranged around the dark-

brown thread-like columella which are as long as sori. Sori are 2-4 cm long and 2 mm broad and destroy the whole inflorescence.

Ustilago andropogonis finitimi also causes a smut of *C. flexuosus*.

The following diseases have been reported on *C. citratus*. (i) *Helminthosporium cymbopogi* causes a very serious disease in the low lands of Guatemala; (ii) Rust is caused by *Puccinia cymbopogonis* (iii) Eye-spot disease is caused by *Helminthosporium sacchari*; (iv) *Curvularia lunata* infects leaves and leaf sheath; causing a leaf spot.

DISTILLATION

For good quality oil, it is advisable to use steam-distillation. To obtain the maximum yield of oil and facilitate release of oil, the grass is chopped into shorter lengths. Chopping the grass, has further advantages that more grass can be charged into the still and even packing is facilitated. The grass should be packed firmly as this prevents the formation of steam channels. The steam is allowed to pass into the still with a steam pressure from 18 to 32 kg in the boiler.

STORAGE

The oil is stored in containers, preferably of glass or welltinned iron. Containers should completely be filled to exclude any air and protected from the sunlight as they affect the citral content. Filtering the oil too often in open air affects the citral content. The oil should be free from moisture.

OIL CONTENT AND OIL YIELD

The yield of grass and the oil content in the grass depend upon the fertility of the soil, climatic conditions, age of the grass, time of cutting, the state of the grass distilled, whether fresh or dry, distillation method, etc.

The yield of grass is the lowest in the 1st year and highest in the 3rd and the 4th year after planting. On an average, one hectare produces 75-100 kg of oil. The percentage yield based on fresh weight varies between 0.2 and 0.4.

CHEMICAL CONSTITUENTS AND USES

As mentioned earlier, the oil from both plants - *C. flexuosus* and *C. citratus* contain chiefly 75-85%. Other minor constituents present in oil obtained from *Cymbopogon flexuosus* are:

Allo-ocimene
Borneol
γ-Cadinene
Caryophyllene
Citral-a
Citral-b
Citronellal
ρ-Cymene
Decanal
Decyl aldehyde
Farnesol
Farnesal
Fenchone
Geraniol
Geranyl acetate
Germacrene D
Limonene
Linalool
β-Methyl hept-5-en-2-one
Methyl heptenone
Myrcene
Nerolidol
Nerol
Ocimene
Terpinen-4-ol
β-Terpineol
α -Terpineol
α -Terpinyl acetate
γ-Terpinene
Terpinolene

The oil is used for the isolation of citral for manufacturing Vitamin-A. Citral is the starting material for the manufacture of lonones and is also used in flavours, cosmetics and perfumes. A small amount of oil is used, as such, in soaps, detergents and other preparations.

In some countries, the grass is cultivated for flavouring food, such as chicken. It is often used for flavouring tea and also added to bath water.

The spent lemongrass is suitable for making paper. It is also used as fuel for the distillation of the grass. It is an excellent source of manure. It is applied either after composting or in the form of ash by burning. It may be used for mulching coffee. It is a good crop for checking soil erosion.

OIL OF GERANIUM

INTRODUCTION

Geranium, *Pelargonium graveolens* L. 'Her. ex Ait. *syn. P. roseum* Willd. (Fam. *Geraneaceae*) is the source of one of the most important essential oils called the oil of geranium, which is widely employed in the soap, perfumery and cosmetic industries. The plant belongs to the group of scented – leaved geranium known mostly as rose geraniums. The other species of *Pelargonium* such as *P. radula, P. fragrans,* etc., which also come under the group of scented – leaved geraniums, are of lesser im – portance and have not attained any commercial significance. *P. graveolens* is distinctly different from the horticultural geraniums which are basically ornamental plants and have no commercial importance whatsoever in the perfumery trade.

Geranium is a native of Cape Province. It is grown in France, Belgium, Spain, Morocco, Madagascar, Reunion Island, Egypt, Congo, USSR, India, for the production of geranium oil.

BOTANY

Geranium is suffrutescent, bushy, aromatic plant. Stem cylindrical, woody at base, pubescent, green when young, turning brown with age. Leaves alternate, stipulate, simple, broadly cordate, chartaceous, with about 5 palmatisect primary lobes and pinnatisect secondary lobes, pubescent on both surfaces, highly aromatic; stipules lateral, free, subtriangular, acute. Inflorescence leaf opposed, bracteate, umbellate; peduncle terete, hairy, longer than petiole; pedicels shorter than flowers; bracts free, ciliate on outerside, forming an involucre. Flowers pentamerous, basically bisexual, hypogynous; calyx of free quincuncial, hairy sepals; corolla pink, zygomorphic, polypetalous, two posterior petals larger, with reddish – purple markings, anterior petal outermost; stamens 10, filaments subequal, united at base; anthers generally seven, dithecous, shed easily; ovary hairy, superior, pentacarpellary, syncarpous, style hairy, breaking up distally into five stigmata.

SOIL AND CLIMATE

Geranium thrives best in well – drained porous soils. It can grow in temperate, subtropical and tropical climates, but flourishes best in Mediterranean type of mild climate with low humidity, warm winter and mild summer temperature having annual rainfall ranging from 1,000 – 15,000 mm.

PREPARATION OF LAND

The land should be properly prepared by discing, tilling, application of fertilisers, laying the field into ridges and furrows and irrigating the plot on the previous day.

PROPAGATION

There is no seed setting in geranium; vegetative propagation is, therefore, the only alternative. The cuttings are first raised in a nursery and then transplanted in the field.

a. Raising of rooted cuttings in nursery

A nursery area of about 80 sq m is sufficient for planting one hectare crop. Nursery beds of about 3 x 1.5 m are prepared by thoroughly working up the soil and mixing enough sand so that a porous medium for the seedlings is ensured up to a depth of about 12.5 cm. About 100 g of super – phosphate is also mixed well into the surface soil of each bed. Fresh terminal cuttings, about 20 cm long and consisting of about 8 nodes are taken from healthy and wellgrown geranium plants. These are transferred to shade immediately and trimmed by removing all leaves except the first 3 – 4 from

the terminal end. A slant cut is made with a sharp knife just below the 6th or 7th node and the cuttings are dipped in 0.03% Benomyl solution for 10 – 20 seconds. 4 – (Indol – 3 – yl) butyric acid (Seradix B – 2), a rooting hormone, is applied to the cut end to encourage early rooting. The nursery beds are watered and then cuttings are planted with the help of a suitable dibber at about 5 cm spacing. The beds are again hand watered without any delay. Watering is carried out daily, twice during the first 3 – 4 days and once in a day subsequently. Geranium being very delicate, wilts under hot sun. The cuttings should, therefore, be made with great care and the nursery areas should be properly sheltered against hot sun. Bright sun, heavy wind and rains damage the cuttings and result in poor establishment. Considering all this, November, December and January months are best suited for raising geranium nursery. However, with adequate precautions, nursery can be raised during other months also. The cuttings will be ready for transplanting in about two months from planting. If propagation is undertaken in a mist chamber with a mist duration of about 10 seconds in every 5 minutes, rooting of the cuttings can be accomplished within about 20 days time. The use of mist chamber would also circumvent the climatic hazards in raising nursery.

b. Transplantation

Rooted cuttings are carefully dug out from the nursery, dipped in 0.03% Benomyl solution and immediately planted. Planting is done at 60 x 60 cm spacing and the planted beds are immediately irrigated. Although the seedlings may droop initially, they will recover by the following morning.

FERTILIZER APPLICATION

In areas where cheap farmyard manure or compost is available, 10 tonnes of well – rotten manure should be mixed in the soil before planting. 35 kg each of N, P_2O_5 and K_2O should also be applied as basal dose. A dose of nitrogen at 35 kg/ha is applied about two months after the first application. Likewise, nitrogen is applied in two equal split doses for each harvest; the first dose being just after the crop is harvested and the second being two months later. In total, 200 kg of N/ha/ year is applied to the crop in six equal doses to cover the three harvests. The doses of manure and fertilisers as above are repeated during the subsequent years.

INTERCULTURE

The crop may require one weeding after about 1½ months from planting and one hoeing after each harvest.

IRRIGATION

The plot is irrigated soon after planting and it is kept moist by frequent irrigations. In all 10 to 12 irrigations are required during rain – free days.

HARVESTING

Geranium is harvested about 4 months from transplanting, when the leaves begin to turn light green and exhibit a change from lemon – like odour to that of rose. The change in colour and odour are criteria for harvesting and calls for careful observations and experience.

Green leafy shoots are harvested with a sharp sickle and taken up for distillation immediately. The use of sharp sickle is important since it minimises the jerks, pulls and damage to the crop while harvesting. The crop after harvest is maintained by hoeing, fertiliser application and irrigation as per schedule. It puts forth fresh shoots, grows fast and reaches harvesting stage in four months. Thus, a total of three harvests in a year may be obtained. The crop is a perennial and can give good harvest for 3 – 6 years.

PESTS AND DISEASES

Wilt of Geranium is observed very often on the crop. It is a vascular wilt caused by *Fusarium* species, a soil – borne fungus. In the beginning, only a few plants exhibit the typical wilting and drooping symptom, which soon attains alarming rate if ignored. The wild outbreak could be minimised by observing the following package of control measures :

i) At the time of planting fresh cuttings in nursery beds, the cuttings are dipped in 0.03% benomyl.

ii) Rooted cuttings are dipped again in 0.03% benomyl, just prior to transplanting.

iii) Benomyl 0.03% is sprayed to the crop after the harvest.

iv) Overwatering increases the incidence of wilt. Minimum irrigation and proper hoeing results in healthy growth.

v) Sharp sickles are used for harvesting so that jerks and pulls are avoided, which can other – wise cause damage to the stem near the ground and pave the way for infection.

The crop is prone to termite attack occasionally. This can be easily controlled by mixing 25 kg/ha of 5% B.H.C. into the soil and irrigating the area.

There is no pest attack on the crop.

DISTILLATION

Geranium is distilled soon after it is harvested. Distillation is carried out at atmospheric pressure and each distillation takes about 2 – 3 hours excluding the time required for loading and unloading. Steam distillation gives better quality oil as compared to hydrodistilled.

OIL CONTENT AND OIL YIELD

Quality and yield of oil will be better if the crop is harvested at appropriate maturity.

The oil is presented mostly in the leaf blades and there is practically no oil in the stem, particularly in the woody parts.

In large – scale distillations, the yield of oil varies from 0.1 to 1.15% on fresh weight basis and an average yield of 0.12% may be considered satisfactory.

The yield of fresh herbage per hectare per year from all the three harvests is about 15 tonnes which on distillation yields about 18 – 20 kg of oil per ha.

CHEMICAL CONSTITUENTS AND USES

The chief constituents are rhodinol (1 – citronellol) (30 – 50%) and geraniol. Other minor/trace constituents are :

Acetaldehyde
Acetone
β—Bisabolene
Bois—de—rose oxide
Borneol
β—Bourbonene
Butanal
α—Bourbonene
Butane
Limonene
Linalool
Menthol
Menthanol
Menthone
3—Methyl butanol
3—Methyl—2—butanone
2—Methyl—butyl formate
Methyl butyrate

2--Butanone
Butyl formate
δ—Cadinene
γ—Cadinene
α—Calacorene
Calamenene
Caryophyllene
Citronellyl acetate
Citronellyl formate
Citronellyl diethylamine
Copaene
ρ—Cymene
Dimethyl sulphide
10—Epi-γ—eudesmol
Ethanol
Epoxylinalool
Eugenol
Furan
2—Furfural
Furapelagone A and B
Geraniol
Geranyl formate
Geranial
Geranyl acetate
Geranyl tiglate
Guaia—6, 9—diene
3—Hexenol (cis)
3—Hexen—1—ol
Hexane
2—Hexanone
Hexyl formate
7—Hydroxydihydrocitronellol
7—Hydroxy—6, 7—dihydrogeraniol
Isoctane
Isoprene
Isopulegol
Isomenthone
Isopropyl formate
Junenol
Methyl formate
4—Methyl—2—pentanone
2—Methyl propanal
2—Methyl propanol
2—Methyl butanol
2—Methyl butanol trans—2—methyl—3—butanal
2—Methyl—3—buten—2—ol
3—Methyl—butyl formate
3—Methyl—cyclo—pentanone
Methyl heptanone
2—Methyl—3—pentanone
2—Methyl propyl formate
γ—Muurolene
α—Muurolene
Myrcene
Neral
Neoisomenthol
Nerol
11—Nor—bourbonanone
1, 3—Pentadiene
2—Pentanone
6—Oxo—6, 7—dihydrocitronellic acid
Pentalol
β—Phellandrene
α—Pinene
2—Propanol
α—Phellandrene
Phenyl ethyl alcohol
β—Pinene
Propyl formate
cis—Rose oxide
trans—Rose oxide
Sabinene
β—Selinene
tert. Butanol
11—Selinen—4—α—ol
α—Terpineol
Tuluene
Rhodinol

The oil of geranium is a clear liquid with light yellow to light brown or green colour. It has a strong, heavy rose – like odour with a minty top note. It blends well in all kinds of scents, floral as well as oriental and is used extensively in perfumery. It is widely used in the scenting of soaps due to its stability in slightly alkaline medium also. Geranium oil is also used for the production of rhodinol. Rhodinol ex geranium oil is very highly priced and is considered valuable for the creation of perfume compounds.

Eucalyptus citriodora Hook. A young tree

OIL OF EUCALYPTUS CITRIODORA

AND

OIL OF EUCALYPTUS GLOBULUS

INTRCDUCTION

The word 'Eucalyptus' is derived from two Greek words, 'eu,' meaning 'Well' and 'Kalypts', meaning 'I cover', based on the nature of the lid covering the flowers before blooming.

The gunus *Eucalyptus* contains more than 700 species. Some of them provide timbers of great beauty and usefulness whereas others are utilized as firewood; some yield honey, whereas others are of medicinal value, or volatile oils possessing fragrances varying from camphor, thymol, peppermint to rose and lemongrass, whilst a few yield flowers of great beauty and colour.

In Australia, Eucalyptus oils are obtained under the three main heads : Medicinal, industrial and perfumery oils. The Eucalyptus trees are mainly grown as a source of timber and the above oils are obtained from the leaves when the trees are felled. Among the medicinal oils, *Eucalyptus globulus*, *Eucalyptus dives* Var. 'C', and *Eucalyptus smithii* are important and they contain 70 – 80% of cineol as principal constituent. Industrial oils are obtained from *Eucalyptus dives*, type which contains piperitone and phellandrene as the principal constituents; *Eucalyptus dives* Var. A contains phellandrene as the major principal constituent. Perfumery oils are obtained from *E. macarthuri* and *E. citriodora*. The oil from the former contains geranyl acetate, geraniol and eudesmol as the principal constituents, whereas the oil from *E. citriodora* contains citronellal as the major constituent.

E. citriodora is commonly known as 'Lemon – scented Gum', 'Spotted Gum', or 'Citron – scented Gum'. It is being grown in Seychelle Islands, Java, South Africa, Guatemala, China, the Congo Republic, Portugal, Brazil and India.

E. globulus is indigenous to Eastern Australia and Tasmania and is cultivated in Spain, Portugal, China, Angola, South Africa, Australia and India.

SOIL AND CLIMATE

E. citriodora is found on poor gravelly soils up to an altitude of 600 m, in rainfed areas. However, it can grow in almost any soil. It is frost – tender in early stages. Tropical and subtropical, but grows satisfactorily in temperate regions.

E. globulus is found mainly on loamy soils with adequate moisture, from sea level to 450 m elevation.

Close – up of a twig of *Eucalyptus citriodora*

BOTANY

E. citriodora Hook. Tall, graceful, shaft – like tree, 25 to 40 m high.

Bark : Smooth, white to pinkish, deciduous.

Juvenile leaves : Opposite for a large number of pairs, 7 to 16 × 4 to 9 cm, broadly lanceolate to oblong – lanceolate, rough and with bristle – like hairs, petiolate.

Adult leaves : Alternate, 10 to 25 × 1 to 4 cm, narrowly to broadly lanceolate, concolorous, petiolate. Venation moderately conspicuous; intramarginal vein not distinct from margin, laternal veins at 40 to 60° angles to the mid – rib.

Inflorescence : Usually an axillary, corymbose panicle; umbels 3 to 5 - flowered, on terete, 5 to 7 mm long peduncles. Buds 10 to 12 × 7 to 8 mm, pedicellate. Operculum hemispherical, shorter than the ovoid receptacle.

Fruit : On pedicels up to 10 mm long, 10 × 10 mm, urceolate to ovoid. Valves 3 to 4, enclosed; disc wide and depressed.

E. globulus Labill. Tree up to 55 m high.

Bark : Blue - grey, smooth, persistent at extreme base of tree.

Juvenile leaves : Opposite for 4 or 5 pairs with a few peltate, 7 to 15 × 3 to 6 cm or longers, oblong to oblong - lanceolate, rough and with bristle - like hairs, petiolate.

Adult leaves : Alternate, 10 to 30 × 30 to 4 cm, or longer, narrowly lanceolate to lanceolate, falcate, lustrous deep green, concolorous, coriaceous, petiolate. Venation moderately conspicuous; laternal veins at 30 to 40° angles to the mid – rib.

Inflorescence : Axillary, usually solitary, but occasionally in 3 - flowered umbels, on a very short or rudimentary peduncle. Buds up to 30 × 20 mm, glaucous, sessile. Operculum flattened – hemispherical, peaked, thick and warty, shorter than the warty, quadrangular, broadly conical receptacle.

Fruit : Sessile or almost so, 10 to 15 × 15 to 30 cm, globular to broadly conical, 4 - ribbed, warty. Valves usually 3 to 5, also 6, more or less at rim level; disc wide, convex or more or less flat.

PREPARATION OF LAND

The land should be levelled and freed from boulders and stones for normal growth of roots. The land should be ploughed 2 – 3 times and pulverised well. Grass and other vegetation on the land should be collected and removed to make it weed – free to the maximum possible extent. Slopes should be terraced to make subsequent application of fertilizers and irrigation for the crop. The final preparation of the land should be preceded by applying a basal dose of superphosphate @ 60 kg/ha.

PROPAGATION

It is raised through seeds only. Only bold and healthy seeds should be used. Shrivelled seeds should be discarded. Seeds germinate in 4 – 14 days depending upon atmospheric humidity and temperature. However, cold – stored seeds germinate even in 2 – 4 days. A commercial cultivation of the crop requires either raising a nursery or alternatively direct seeding the well prepared field in proper season.

i) Propagation through raising of nursery plants

Raising the nursery

The nursery is raised on raised beds or even in trays filled with soil. A permeable sandy loam soil is the best. The nursery should not be rich in humus as it promotes damping – off disease under humid conditions. It requires protection from direct sun and rain. Soil should be weeded, pulverised and levelled before seeding. Care is to be taken, while sowing, that seeds do not go deeper than 1 cm under soil, or else they may not germinate. Line sowing is advantageous for subsequent agricultural operations. After sowing, the seeds should be lightly covered with soil by gentle working with hand and irrigated so as to keep the soil fairly moist till the commencement of germination. Thereafter, the nursery should occasionally be irrigated to keep it just moist. Seedlings, with 2 – 4 pairs of leaves (about 2 – 3 cm tall), and 4 – 6 weeks after seed sowing, are at the proper stage for trasplanting. Older seedlings develop an extensive root – system are therefore very sensitive to even a mild disturbance resulting in very high mortality. Individual seedlings are picked out on a spatula with a ball of earth attached and 4 – 5 seedlings are transplanted in each polythene bag, 15 cm long and 10 – 12 cm broad, filled with nursery – type of soil, followed by irrigation. These seedlings are allowed to grow for 2 – 6 months in the bags depending upon the season.

Nursery can also be raised directly in bags. About ten seeds are sown in each bag, mixed with soil and irrigated. Plant population can be thinned out after germination and plants grown as such for 2 – 6 months as in the earlier case. This method is better and economical than the conventional method of raising nursery since the cost of raising nursery in beds and transplanting in bags is eliminated besides reducing the risk of mortality after transplanting in bags.

Transplanting

When the seedlings attain average height of 30 cm, polythene cover may be slitted or even completely removed and seedlings with ball of earth intact are transplanted, without disturbing the roots, in pits at predetermined spaces. If possible, a handful of farmyard manure should be put in each pit before transplanting the seedlings. The space around the seedlings is compactly filled with earth and irrigated the same day.

A spacing of 1 – 1.5 m between rows and 75 cm – 1 m between pits is the best for raising a commercial crop. Initially each pit will have 4 – 5 plants and the population can be thinned out subsequently. Transplanting in field is preferable in August or early September in frost – free regions. This timing will allow sufficient time for the young plants to establish and to withstand the adversities of winter. Regions experiencing frost during winters would not be suited for August – September transplanting. February is the best for transplanting in such areas. The plants will grow quite fast during subsequent months and will be able to survive during summers with even light irrigation. By advent of rainy season these plants would have grown to a height and strength enough to withstand any physical damage due to heavy rain and even fungal attack. Mortalities, if any, can be replaced towards the end of the rainy season.

ii) Direct sowing in field

The raising of nursery and transplanting the seedlings can be eliminated completely by sowing seeds directly in the field. However, this method requires a very good preparation of land, thorough removal of grass,followed by sowing in rows at 90 cm and irrigation.It is better to prepare small ridges, about 10 cm high and 10 cm wide, 90 cm apart and seeds sown on the ridges. This method prevents seeds from drifting away on irrigation. Sudden rains or heavy irrigation also does not affect the crop sown on ridges. Seeds can be sown in February and September. The plantation can be thinned according to requirements. This method is cheaper than raising nursery and transplanting seedlings. However, it cannot be adopted in regions exposed to heavy rainfall and frost.

FERTILIZER AND ITS APPLICATION

The available data on fertilizer requirements of eucalypts in general is very scanty. Nitrogenous fertilizers contribute positively towards increased production of leaves which indirectly increase oil production per unit area. The fertilizer has no bearing with the percentage of oil in leaves. Phosphate and potash fertilizers do not appear to have any effect on the crop and hence are not recommended for regular use unless the soils are very deficient in these ingredients. However, in due course of time the soil becomes depleted in the essential ingredients which subsequently causes deficiency diseases. Hence, a small dose of phosphatic and potash fertilizers should be given to the plantation every year. It is, accordingly, suggested that in irrigated areas about 20 kg N, 30 kg P and 30 kg K per ha should be applied at the time of ploughing as basal dose. Three top dressings of N in the form of urea or ammonium sulphate should be given @ 20 kg per ha preferably after every harvest. Fertilizer application should necessary be followed by irrigation. In rainfed areas fertilizer should be applied during rains. The above dose of fertilizers be repeated every year.

INTERCULTURE

To check weed control the plantation requires hoeing during the first year. The roots of the plants grow quite deep after a year and weeds do not pose any threat to the plantation. Moreover, regular subsequent agricultural operations keep the weeds under control.

PESTS AND DISEASES

Certain areas are known for termite menace. If the soil is dry for a considerable time, termites eat away the roots and bark of the stem causing plant mortality. It is, therefore, essential to treat the soil with Eldrin mixed with water or 0.1 – 0.2% aqueous solution of eldrin or Chlordane besides not allowing the soil to remain dry for more than a fortnight.

DISEASES AND PESTS

The hairy caterpillar feeds on leaves of *E. citriodora* in early stages and can be controlled by timely spray of BHC powder on leaves. Certain fungal diseases seriously affect the plant. *Fusarium orthoceros* Appel and Wollenweber attacks the seedlings at the hypocotyl level in the rainy season. Excessive humus content of the soil promotes the disease and entire nursery perishes overnight. The fungus *Colletotrichum* sp. attacks leaves. The leaves turn brown and die with the spread of the fungus. Aqueous spray of Micop (0.2%) or any other copper fungicide controls the disease. The fungus *Cylindrocladium* Morg. causes blight of *E. citriodora*. The leaves and stems of seedlings get severe infection and ultimately causes death of the plant. Symptoms consist of irregular dark brown spots on leaves which enlarge rapidly in moisture. *Physalospora latitans* Sacc. infects the leaf; the disease appears with discolouration of leaves and appearance of sharp, conspicuous, black, circular spots, measuring 1 – 2.5 m, in diameter, on both sides of the leaves. The leaves get dried and finally defoliation takes place. Some viral infections cause phyllody (little leaf); leaves turn pink or yellow. Some other mosaic symptoms have been observed. Plants showing these symptoms should immediately be plucked and destroyed.

In case of *E. globulus*, Chalcid *Rhicnopeltella eucalypti* infests the twig of the tree. Feeding of the insect's larvae results in extensive damage. The beetle *Paropsis dilatata*, the snout beetle of the genus *Goniperus* and the scale *Eriococcus coriaceus* is found causing damage to the plant. The moth *Mnesampela privata* Guenee is a frequent infester of the tips of the saplings. The psyllid *Ctenarytaina eucalypti* (Mask.) infects the plant, particularly in the seedling stage and forms silky – white filaments on the young foliage. The fungus *Stereum hirsutum* (Willd.) Pers. is a parasitic on the sapwood and causes a heart – rot.

HARVESTING

The leaves of *E. citriodora* should be harvested when they are rich in oil – content and weather is also quite clear. Cloudy as well as rainy days are unsuitable for harvesting. The first harvest can be taken from 6 – 8 month – old plantation. At this stage the yield of the herb as well as of the oil is rather negligible, but coppicing the plants is necessary since it promotes a vigorous sprouting of side branchings. Fresh shoots sprout in about four weeks after coppicing which are again ready for coppicing after 4 – 5 months. The process results in regular increase in yield of leaves which is almost stabilized when plants are 3 years old. The first coppicing is done at about 30 – 45 cm aboveground and the subsequent ones are done at 75 – 90 cm aboveground. This level of coppicing is advantageous for subsequent cultural operations. Usually three harvests can be taken annually from the irrigated plantations. This stage is reached during middle of February to middle of March, middle of July and end of October to early November. After two years, the plantation can be thinned to one plant per pit so that new shoots get enough space and nourishment to grow normally.

The Australian method of coppicing plants at about 15 cm aboveground makes each plant a huge bush even from the ground level. This requires more spacing between plants and the number of plants per acre is accordingly reduced. At the above spacing and coppicing the yield of green herb per ha during the first year is about 7 tonnes, during the second year about 30 tonnes and about 40 tonnes during the third year in irrigated areas. This yield is almost stabilized after this age and a plantation is expected to remain economical for about ten years if properly maintained. From unirrigated rainfed areas only two harvests with nearly 37 tonnes of green herb per ha per year is possible.

DISTILLATION

The harvested material should immediately be separated from hard, thick wood since leaves attached to thinner branches are suitable for distillation.

The leaves are steam distilled for the oil. It is advisable to distill the herb soon after harvesting to avoid loss of oil through evaporation as well as its deterioration in quality during storage.

In case of *E. globulus*, trees are usually felled as the gathering of leaves from live trees is difficult and costly and feasible only when the oil brings high prices. Sometimes however, leaves are collected from old live trees that contain abundant foliage. The leaves are distilled throughout the year, the period of distillation depending upon the use to which the wood can be put. The most favourable time for distillation is from April to September, because the yield of oil then averages 0.8%, and the cineole content of the oil is 63 to 73%. During the winter months the yield of oil drops to about 0.7% and the cineole content to 60 - 65%.

OIL CONTENT AND OIL YIELD

The nature of the soil, the age of the plants, the distance between the trees, the cultural care and prevailing weather influence the yield of leaves and oil. In case of *E. citriodora*, a yield ranges from 0.5 to 2%. In Australia, the leaves and terminal branchlets of forest trees yield from 0.5 to 0.75%, those of isolated trees from 1 to 1.3% of oil, cultivated trees yield up to 2.0%. In Brazil, yield of oil varies from 0.8 to 1.2%. In Guatemala, the yield of oil amounts to about 1.5%. Oil content as high as 4.80% has been reported from plants growing in Nigeria. In India, oil content ranges from 0.5 to 2.0%.

As mentioned under 'Distillation', the oil yield in case of *E. globulus*, in summer is about 0.8%, whereas it is about 0.7% in winter. The highest yield of oil comes from the top leaves of the trees; this oil has a better solubility and a higher cineole content than the oil from the lower leaves. A tree six to eight years old yields 30 to 60 kg of leaves per year.

CHEMICAL COMPOSITION AND USES

The major constituents of *E. citriodora* are citronellal (65 – 80%) and citronellol (15 – 20%). Other constituents reported are :

Aromadendrene	Hydroxycitronellal
Camphene	Isopulegol
Carvone	Limonene
Caryophyllene	Linalool
1, 8 – Cineol	Myrcene
Citral	Neoisopulegol
Citronellyl acetate	α – Pinene
p – Cymene	β – Pinene
Eudesmol	γ – Terpinene
Eugenol	Terpinolene
Geraniol	

In case of oil of *Eucalyptus globulus*, the chief constituent is cineol. Other constituents as reported in California oil are :

Alloaromadendrene	Piperitone
Aromadendrene	β – Pinene
γ – Cadinene	Terpinen – 4 – ol
Eremophilene	α – Terpinene
Globulol	β – Terpinene
α – Gurjunene	γ – Terpinene
Linalool oxide	

Oil of *Eucalyptus citriodora* is used in perfumery and as a source of citronellal for manufacture of citronellol, hydroxy – citronellal and menthol. A small quantity of oil is added in germicides and disinfectants to improve their odour. It is an effective substitute for Java citronella oil and also used in soap and cosmetics industry.

Eucalyptus globulus oil is an active germicide, though less active than many other volatile oils. It is used locally as an antiseptic, especially in the treatment of infections of the upper respiratory tract and in certain types of skin diseases. Internally it has found use as a stimulating expectorant in chronic bronchitis. Sometimes it has been administered by inhalation; a few drops of the oil are added to boiling water and the mixture of oil vapor and steam inhaled. The oil is also included in some for – mulations which are inhaled directly, without the use of steam. It has been employed in asthma, either by internal administration or by inhalation. It has also been used as a vermifuge, against the hook – worm.

The wood of both species are used as mine props, railway sleepers and in construction of houses. The wood has an excellent pulping property and can be used in paper industry.

OIL FROM MINTS

INTRODUCTION

Mints are a group of plants belonging to family *Labiatae*, which yield essential oils on distillation. The mints, which are being cultivated commercially in various parts of the world are: Japanese mint (*Mentha arvensis* Linn. subsp. haplocalyx Briquet var. *piperascens* Holmes), peppermint (*Mentha piperita* L.) and spearmint (*Mentha spicata* L.). Recently a fourth species, *Mentha citrata* Ehrh. called Bergamot mint, has also come into commercial production, which yields Bergamot type oil containing 40% linalyl acetate.

Japanese mint is a source of menthol, which is used extensively in medicine, food and cosmetics. The oil of peppermint, which contains less menthol but has a sweeter aroma and taste, is used in tooth-pastes, chewing gums, candies and high grade liquors (alcoholic beverages). Peppermint oil is preferred for use in medicine and pharmaceutical preparations such as cough syrups and lozenges. Spearmint is used mostly as a spice and its oil is used for flavouring, whereas *M. citrata* oil is used mostly in perfumery because of its higher content of linalyl acetate and linalool.

Japanese mint is cultivated on large scale in Brazil, Paraguay, China, Argentina, Japan, Thailand, Angola and India. Peppermint is grown in USA, Morocco, Argentina, Australia, France, USSR, Bulgaria, Czechoslovakia, Hungary, Italy, Switzerland and on a smaller scale in most of the European countries USA is the principal producer of peppermint oil in the world. Spearmint is mostly cultivated in USA in the States of Indiana, Michigan and Oregon.

BOTANY

Mints are perennial plants with quadrangular stem. Essential oil is borne in the glands of leaves present in the subcuticular region. The plants blossom profusely but rarely set seed. The plants reproduce readily vegetatively through the underground parts called stolons which grow underground at a depth of 15 cm and spread in all directions.

Japanese mint

The Japanese mint of today is botanically known as *Mentha arvensis* L. subsp. *haplocalyx* Briquet var. *piperascens* Holmes. The plant is downy perennial herb with root stock creeping along or just under the ground surface. It has a rigid branching, pubescent, 60-90 cm tall stem. The leaves are lanceolate to oblong, sharply toothed, 3.7-10 cm long, sessile or shortly (3-10 mm) petioled, covered with small whitish hairs and glandular dots on both surfaces. Cymes of verticilate purplish flowers occur on rather distant nodes. Cymes are usually sessile or rarely pedunculate which may be glabrous or pubescent. Calyx 2.5-3 mm long, narrowly deltoid, acuminate. Corolla white to purple, 4-5 mm long.

The plant is a high numbered polyploid with 96 chromosomes. It is a clonal form hybrid perpetuated by vegetative propagation. The plant is a hybrid between *M. arvensis* L. and *M. aquatica* L. and is more robust than the parents. Out of the three horticultural varieties of the Japanese mint, the one with reddish purple stem and broad obtuse leaves is best with regard to menthol content. However, its two Japanese names AKA KUI and AKA MARU, create some confusion. The other two varieties are; (i) with green stem, broad or narrow leaves and (ii) with purplish green stem and narrow leaves.

Peppermint (*Mentha piperita* L.)

M. piperita L. is a native of Mediterranean region and has naturalized in Europe, Asia, North America and Australia. The plant is a perennial, glabrous herb with strong pepper-like pungent odour and hence the specific name "piperita". The plant propagates through horizontal, white underground stolons from which several aerial branches arise.

Two varieties of the species are usually recognized. These are *M. piperita* L. var. *officinalis* Sole subvar. *pallescens* Camus will green stem, and the other is *M. piperita* var. *officinalis* Sole subvar. *rubescens* Camus having violet brown stem. The former is referred as white mint and produces oil of inferior quality, while the latter called Mitcham mint or black mint produces better quality of oil. Both of these are identical in other characters. Stem is erect, 30-90 cm tall, branched, quadrangular, naked or rarely covered with trichomes. Leaves are opposite, petiolate, ovate to oblong, lanceolate, 2.5-7.5 cm long, acute or obtuse at the base, serrate, glabrous or pubescent along dorsal veins and punctate with minute oil globules, dark green glabrous ventral surface. Flowers purplish, in thick 2.5-7.5 cm long terminal spikes. Calyx resinous, dotted and glabrous below with teeth usually ciliate. Corolla is purple, rarely white, nearly 1/3 cm long and glabrous.

M. piperita L. is regarded as a natural hybrid between *M. spicata* L. (48 chromosomes) and *M. aquatica* L. (96 chromosomes). *M. spicata* itself is a hybrid of *M. longifolia* Huds. and *M. rotundifolia* L. Thus *M. piperita* can be regarded as a triple hybrid. Its chromosome numbers are highly variable, 2n = 36, 48, 64, 65, 66, 70, 72 and 84.

Bergamot Mint (*M. citrata* Ehrh.)

Mentha citrata Ehrh. is a native of Europe and has naturalized in Eastern USA and also cultivated in some other countries. The plant is commonly known as "Orange Mint" and "Bergamot Mint". It is a 30-60 cm tall perennial plant with decumbent branches and erect ends. It multiplies through hardy square stolons. The leaves are 1.25-5 cm long, thin, bronzy green, petiolate, smooth, broadly ovate to elliptical and apex obtuse. The uppermost leaf is lanceolate with acute apex. Flowers are purple, appearing in upper axils on short dense terminal spikes. Calyx is glabrous with subulate teeth while corolla is glabrous and about 0.5 cm long.

M. citrata is a hybrid between *M. aquatica* L. and *M. viridis* L. It is sometimes described as identical with *M. aquatica*.

Spearmint (*Mentha spicata* L.)

M. spicata L. is indigenous to Northern England and is known by several names such as *M. spicata* var. *viridis* L., *M. viridis* L., Spearmint, Garden Mint and Lamb Mint, etc. The plant is now grown practically all over the world. Like other mints, *M. spicata* is also perennial propagating by stolons from which 30-60 cm erect ascending branches arise. Leaves are sessile or nearly so, smooth, lanceolate or ovate-lanceolate, sharply serrate, smooth above and glandular below, acute apex and upto 6.5 cm long. The leaves possess a characteristic odour and pungent taste, lacking cooling after-effect in contrast to that of peppermint. Flowers are lilac in loose, cylindrical, 5-10 cm long spikes. The spikes are sharply pointed, long and narrow and hence the name spearmint attributed to the plant. Calyx teeth are hirsute or glabrous and corolla about 3 mm long.

M. spicata differs from *M. piperita* in certain marked characters. The stem of the former is always shorter and stands more erect as against the latter. Further the lance-shaped leaves of the former are narrower, lighter green in colour and mostly sessile than those of *M. piperita*.

This species is very variable in morphological characters and is often erroneously named as *M. viridis*. The species is a hybrid between *M. rotundifolia* L. and *M. longifolia* Huds. Its chromosome numbers also vary; 2n = 36, 48 and 84.

Close-up of a twig of *Mentha spicata*

SOIL AND CLIMATE

Japanese mint can be grown in a wide range of soils and climatic conditions in all tropical and subtropical areas, provided adequate irrigation facilities are available. However, sandy or heavy clay soils do not support good growth of the crop. The crop thrives well in medium, deep soil rich in humus. The soil should have good water-holding capacity but waterlogging should be avoided. pH range 6-7.5 is ideal for Japanese mint. Highly alkaline soils are not suitable. Peppermint has the same soil requirement as that of Japanese mint, but it cannot be grown profitably in tropical and sub-tropical areas, specially with very high summer temperature (105°F or 41°C) and the optimum yields are obtained only in temperate conditions. Bergamot mint can be grown both in temperate as well as sub-tropical areas. However, the performance is better in temperate climate. Spearmint can be grown in all those areas where peppermint is grown.

PREPARATION OF LAND

Mints require a fine seed-bed. Soil, therefore, should be ploughed and harrowed thoroughly to get a fine seed-bed. All the stubbles of the weeds should be removed before the crop is planted.

Close-up of a twig of *Mentha spicata*

SOIL AND CLIMATE

Japanese mint can be grown in a wide-range of soils and climatic conditions in all tropical and subtropical areas, provided adequate irrigation facilities are available. However, sandy or heavy clay soils do not support good growth of the crop. The crop thrives well in medium, deep soil rich in humus. The soil should have good water-holding capacity but waterlogging should be avoided. pH range 6-7.5 is ideal for Japanese mint. Highly alkaline soils are not suitable. Peppermint has the same soil requirement as that of Japanese mint, but it cannot be grown profitably in tropical and sub-tropical areas, specially with very high summer temperature (105°F or 41°C) and the optimum yields are obtained only in temperate conditions. Bergamot mint can be grown both in temperate as well as sub-tropical areas. However, the performance is better in temperate climate. Spearmint can be grown in all those areas where peppermint is grown.

PREPARATION OF LAND

Mints require fine seed-bed. Soil, therefore, should be ploughed and harrowed thoroughly to get a fine seed-bed. All the stubbles of the weeds should be removed before the crop is planted.

PROPAGATION

The mints are propagated by means of underground vegetative parts called stolons. In case of peppermint and bergamot mint, runners can also be planted. Stolons are obtained from the plantation of previous year which remains dormant during winter months. The best time for obtaining stolons is the late winter period. The stolons can be taken out either manually by spade or through tractor-drawn cultivator or harrow. After the soil is disturbed, the stolons can be collected by hand. It is better to plant them as soon as they are dug out from the soil. In case these are required to be stored, these are placed in pits and covered with soil, till the field is ready for planting. The stolons can be stored for a fortnight without being damaged. A hectare of well-established mint, on an average, provides enough planting material for 10 hectares.

Mint can be planted on flat land but ridges are preferred. Best time for planting is by the end of winter. The stolons are cut into small pieces about 10 cm long and the diseased or unhealthy pieces are discarded. These are planted in shallow furrows of about 7-10 cm deep at a distance of 45-60 cm from row to row. These can be planted manually in case of small holdings. However, in a mechanized farm, mint can be planted behind a cultivator (spaced at a distance of 45-60 cm) where labourers drop pieces of stolons in the furrows walking behind the tractor. In the same way, it can also be planted behind bullock-drawn cultivator. After planting the furrows are covered by light planking. The soil is irrigated immediately after planting.

The planting method for peppermint, spearmint and bergamot mint is similar. In the plains, planting takes place during winter months, whereas in temperate climate, planting is done in autumn or spring.

On an average, about 400 kg stolons are required for planting one hectare of land. Spacing from row to row varies from 45 to 60 cm depending on the interculture method adopted as well as fertility of the land. Spacing of 40-50 cm is optimum. In case of closer spacing, use of machinery for interculture is difficult.

The crop is irrigated immediately after planting with a view to get good germination; the soil is kept moist thereafter. Stolons take 3-4 weeks to sprout.

FERTILIZER APPLICATION

Mints respond very well to heavy application of nitrogenous fertilizers. Increase in herbage by application of phosphorus is not as remarkable as in case of nitrogen. In poorer soils good results have been obtained after green manuring the field with leguminous crop like Sunhemp (*Crotalaria juncea* Linn.). However, it will not be practicable in the present situations when one wants to make maximum amount of profit and multiple cropping is the general principle.

Application of nitrogenous fertilizers @ 90-120 kg per hectare is required for raising a good crop of mint. When green manuring or farmyard manure is used, quantity of nitrogen in terms of other artificial fertilizers can be decreased proportionally. Yields are better with organic manures like farmyard manure or compost as compared to artificial fertilizers. In deficient soils, 50 kg P_2O_5 and 40 kg K_2O per hectare are applied as basal dose at the time of planting, along with 20 kg nitrogen per hectare. Remaining nitrogen is applied in three equal splits of 20 kg each per hectare. The first dose is applied when the crop is 6 – 8 weeks old and after the first weeding. The second dose is applied four weeks after the first dose and the third dose is applied after the first harvest of the crop.

In case of peppermint, where the crop is maintained for three years, the same dose of nitrogenous fertilizers is repeated every year. However, same dose of phosphorus and potash may not be needed.

INTERCULTURE

Control of weeds is essential for having the optimum yield of mint herb and oil. First hand – weeding is required after four weeks of planting. This is repeated once or twice before the first harvest is taken. It is better to use tractor – drawn harrow to keep the soil disturbed after the hand – weeding, as this will cut down the cost of hand – weeding in future operations. In smaller holdings, hand – hoes or bullock – drawn hoes can be used. After the third weeding, growth of weeds is checked till the first harvest is taken.

In temperate areas, the crop when planted in spring, gives two harvests up to October. The plants become dormant in November. Recultivation is done either in autumn (November – December) or in spring (March – April). Another hand – weeding will be required after the first harvest.

Weedicides can be used profitably in mint farming. Terbacil (Sinbar) is the only weedicide which controls a large number of weeds effectively, when applied as a post – emergence spray @ 1 kg per hectare. In countries where its cost is high, it should not be used specially when hand – weeding is cheaper. However, in those areas where labour is a problem, terbacil can be used effectively. Prometryne as a post – emergence weedicide can be used in temperate areas in case of peppermint.

IRRIGATION

Water requirement of the mints is very high and depending upon the soil on which it is grown, the crop is irrigated 6 – 9 times before the rainy season sets in. During the rainy season, if the rains are regular, no additional irrigation is required. After the rainy season, the crop requires three irrigations. Sometimes another irrigation is required during winters, if the growth is dormant and there are no winter rains, so as to encourage proper growth of underground stems. Peppermint, spearmint or bergamot mint, when grown in temperate climates, require only 3 – 4 irrigations. Waterlogging should be avoided and adequate drainage should be provided so that excess water during rains is drained out. In case of heavy soils and the soils prone to waterlogging, it is better to cultivate mint on ridges.

CROP ROTATION

Continuous cultivation on the same land results into considerable increase in the weed population, soil – borne diseases and insects. In fact, one of the best methods of weed control in mints is to follow a suitable crop rotation. Rotation of mint with rice not only checks a large number of weeds but it also helps in reducing the soil – borne diseases, fungal pathogens and the insects. In case rice cannot be used for rotation, any other food crop which requires clean cultivation, can be used in a three – year rotation in mint farming. Following crops have been found to be quite economical for rotation with mints :

1) Mint – maize – potato
2) Mint – early paddy – potato
3) Mint – late paddy – peas

In case of peppermint cultivation in temperate areas, the crop can be kept for 3 years. The crop which is planted in spring, gives two harvests up to October. The plants become dormant in November. In order to get a perennial crop the recultivation is done either in autumn (November – December) or in spring (March – April). For recultivation, the mint field is tilled either with a harrow or cultivator. Excess of stolons are removed for planting new areas. All the weeds are dug out with roots and the field is irrigated.

HARVESTING

The crop is ready for harvesting after 100 – 120 days of planting. Ideal time for harvesting is the stage when the lower leaves start turning yellow. Any delay beyond this stage results into considerable falling of leaves and subsequent reduction in the oil yield. Further, Japanese mint should be harvested in bright sunny weather. The plants are cut by means of sickle 2 – 3 cm above the ground.

Second crop will be ready for harvesting after about 80 days of first harvest and the third crop will be obtained again after a period of about 80 days from 2nd harvest. It is better to allow the harvested green herb to wither for 24 hours before it is distilled. In case of peppermint, spearmint and bergamot mint, grown in the temperate climates, first crop is generally ready by the end of June and a second crop can be obtained in September or October. Specially in temperate climates, the peppermint crop planted once can be used as a ratoon crop for three years. However, this retention is not economical in case of Japanese mint or bergamot mint, which should be planted every year.

DISEASES AND THEIR CONTROL

Although a large number of diseases of mint are reported from different parts of the world, only 3 diseases have been reported to affect the mint significantly. These are : Rust, Powdery Mildew and Stolon Rot.

Mint Rust (*Puccinia menthae* Pers.)

It is the most important disease, which appears almost everywhere in Japanese mint plantation. Symptoms of the disease which appear during growing period in summer consist of yellowish lemon – coloured blisters on the upper surface of leaves, which are covered with powdery substance consisting of the uredospores of the fungus. In case of severe infection, the leaves turn yellow and fall off. In the later stages, lemon – coloured spots are replaced by compact brownish black spots consisting of the teliospores. Teliospores also occur on the stem. By onset of very high temperature both the uredospores and teliospores disappear as the fungus cannot complete the life – cycle because of the death of teliospores. The disease is a serious problem in peppermint plantations of USA.

Powdery Mildew (*Erysiphe cichoracearum* DC.)

This disease attacks the mint crop during the growing period in localized areas where light and aeration is poor. It has not been observed to occur in a severe form in any of the large commercial farms. Symptoms of the disease consist of powdery white patches on the upper and lower surfaces of the leaves and stems. These patches consist of mycelia and spores of the fungus. Under favourable circumstances, the disease causes severe losses by defoliation and decrease in the oil content up to 50%.

The disease can be controlled successfully by spraying any sulphur formulation or organic fungicide like dinocap (Karathen) and quinomethionate (Morestan). The spraying should be started as soon as the disease appears in the field and repeated every 10 – 15 days.

Stolon Rot (*Macrophomina phaseoli* Hob. Ashy)

The disease first appears during the growing period in May when isolated plants are found wilting. In severe cases the disease causes rotting of the underground stem and death of the entire plant. One of the main damage caused by the disease is the reduction in production of stolons and rotting of the stolons by the end of the cropping season. Such diseased stolons when planted in the field, yield poor germination and causing severe losses due to wilting sprouted plants.

The disease can be controlled by crop rotation. Mint should not be planted continuously in those areas where attack of stolon rot is observed. It is better to follow 3 – year crop rotation with rice, wheat and mint. It is advisable to discard the diseased stolons while planting and treating the stolons with 0.25% solution of captan or benomyl (0.1% Benlate).

INSECT PESTS

A large number of defoliating insects attack Japanese mint crop. Generally these cause very little damage to the crop. However, in localised conditions heavy damage has been observed. Important pests are : (i) Mint Leaf – Roller (*Syngamia abraptalis* Walk.); (ii) Pyralid (*Laphygma exigua* Hub.), and (iii) Hairy caterpillar (*Diacresia obligua* Walk.).

Mint Leaf – Roller (*Syngamia abraptalis* Walk.)

The caterpillar attacks the crop during August – September. They fold the leaf in the form of a roll and feed inside the parenchymatous tissue leaving the lower epidermal portion intact. The edges of the leaves are held together with silk – like filaments. The single caterpillary feeds on 2 – 3 leaves of the same plant before it attains maturity. The fully grown caterpillar measures 22 mm in length with yellowish green body having black spots on dorsolateral, thoracic and abdominal segments.

In severe cases the pest can be controlled by spraying BHC at weekly intervals. 2 – 3 spraying are sufficient to control the pest.

Army – worm – Pyralid (*Laphygma exigua* Hub.)

This is a common pest of a number of agricultural crops, which attacks mint during February, March and April. The larvae of the pest bore into plant and eat the leaf – buds completely. Such leaf – buds are distorted. The pest has been found to cause no serious problem in commercial mint plantations.

Hairy Caterpillar (*Diacresia obligua* Walk.)

This is a polyphagous insect attacking a large number of crop plants. In case of severe attack on other surrounding crops, it also becomes a serious pest of mint. The caterpillar starts eating the undersurface of the leaves. After eating the entire leaf, it migrates to other leaves leaving the epidermis intact. The caterpillar has black head, yellowish hairs and several yellow bands on the body. It is about 5 cm long. These can be often seen crossing the roads and fields.

In case of severe attacks, any common insecticide like malathion can be used for controlling the insect.

DISTILLATION

Oil of mint is obtained by distilling fresh or dry herb. Time required for completing the dis – tillation depends on the size and efficiency of the still, quantity of the steam passed and the condition of the herb. Usually it takes 1½ to 2 hours to complete the process of distillation in a well – designed still having good steam pressure. In case of small – scale farming, a direct fired still can be used. However, it is always desirable to have a boiler and steam operated stills in case of large farms.

OIL CONTENT AND OIL YIELD

Yield of fresh herb depends upon the crop grown. A good crop of Japanese mint can give as high as 48 tonnes of fresh herb per hectare. On an average, 20 – 25 tonnes of green herb per hectare

can be obtained in three cuttings. The fresh leaves contain 0.4 – 0.6% oil. The yield of oil depends on the efficiency of distillation equipment. Taking into consideration all losses by shedding of leaves, etc., a yield of 100 kg oil per hectare can easily be obtained under optimum conditions. However, in large scale farming, average yield of 50 – 75 kg oil per hectare is obtained. Although bergamot mint as well as Japanese mint give an average yield of 75 – 100 kg/ha, yield of peppermint and spearmint is lesser with an average of 50 kg/ha.

ACTIVE CONSTITUENTS AND USES

Chemical composition

Japanese Mint *(M. arvensis)* oil

Main constituents of the oil are menthol, menthone and menthyl acetate. Japanese mint oil contains 65 – 80% menthol depending on the climatic conditions where it is grown. Menthol content is generally higher in tropical areas. Minor constituents of the oil are menthone (7 – 10%), menthyl acetate (12 – 15%) and terpenes (5 – 10%). Terpenes mainly consist of pinene, limonene and camphene.

Peppermint oil *(M. piperita)*

Peppermint oil has almost similar constituents as Japanese mint oil. However, menthol content is lower in peppermint oil, which varies between 35 – 50%. Other constituents are menthyl acetate (14 – 15%), menthone (9 – 25%), menthofuran and terpenes like pinene, limonene.

Bergamot Mint oil *(M. citrata)*

The chief constituents are linalool and linalyl acetate. Other constituents present :

Caryophyllene
Caryophyllene oxide
1, 8 – Cineol
Citronellol
p – Cymene
Geraniol
Geranyl acetate
Geramacrene
α – Humulene
Limonene
cis— Linalool oxide
trans—Linalool oxide
Myrcene
1 – Octen – 3 – yl – acetate
3 – Octyl acetate
β – Pinene
Sabinene
α – Terpineol

Spearmint oil *(M. spicata)*

The main constituent is carvone.

It has been found to contain the following other constituents :

Borneol
β – Bourbonene
γ – Cadinene
δ – Cadinene
Cadinol
Camphene
Carvacrol
trans—Carveol
cis – Carveol
Eugenol
Garnesene
Farnesole
cis – 3 – Hexenyl isovalerate
β – Humulene
Isomenthone
cis—Jasmone
Linalool
Limonene

trans—Carvyl acetate
cis – Carvyl acetate
Caryophyllene
1 – 8 – Cineol
Dihydrocarveol
Dihydrocaryl acetate
Dihydrocarvone
β – Elemene
Elemol
Menthol
Menthone
Nedihydrocarveol
3 – Octanol
3 – Octyl acetate
Perrilyl alcohol
α – Pinene
β – Pinene

cis—Carvyl acetate is the major component responsible for the peculiar odour associated with the Japanese spearmint oil.

USES

Japanese Mint *(M. arvensis)*

Japanese mint is generally cultivated as a primary source of menthol. Menthol is used as a flavouring agent in tooth – pastes, candies, chewing gums and mouth – washes, etc. This is also used as an ingredient in a number of medicinal preparations like ointments, pain balms, cough syrups, cough lozenges and tablets as well as a large number of other medicinal preparations. It is also used as a flavouring agent in a number of beverages and other items like tobacco, cigarettes, confectionery, betelnut flavouring, etc. Menthol is used as a soothing ingredient in a number of cosmetic preparations, colognes, deodorants, after – shave lotions and perfume bases. Mint oil and menthol are also used in flavouring mouth freshners, aerosols, polishes, lipsticks and hair lotions.

Peppermint *(M. piperita)*

Because of its low menthol content, peppermint is generally not used as a source of menthol. However, the oil has a sweeter aroma and taste because of presence of some minor constituents and the oil is used directly as a flavouring agent and is constituent of medicinal preparations, specially cough syrups and certain brands of tooth – pastes, mouth–washes, etc. It is mainly used for flavouring tooth – paste, chewing gum, confectionery, cigarettes, tobacco and cosmetics.

Bergamot Mint *(M. citrata)*

The oil is used directly in perfumes and cosmetics. Linalyl and linalool are important perfumery chemicals used in a number of cosmetic preparations including scents, soaps, after – shave lotions, colognes, etc.

Spearmint *(M. spicata)*

The oil is used mostly as a flavour in tooth – pastes and as a food flavour in pickles and spices, chewing gums and confectionery, soups and sauces.

Close – up *Rosa damascena* Mill. (Rose)

OIL OF ROSA DAMASCENA

Rosa is a large genus of erect, sarmentose or climbing shrubs, widely distributed in the temperate parts of the northern hemisphere and on tropical mountains. The genus includes about 120 or more species, a large majority of which are native to the Asiatic region. Some are found in wild state, some have been introduced as ornamentals.

Out of the various species of *Rosa*, three have been used commercially for production of essential oil. *Rosa damascena* is the most important variety with a delicate fragrance and considerably larger percentage of oil. Most of the high grade rose oil and otto of rose is produced from this species. Bulgaria is the major producer of this rose oil. Turkey and India are the other two countries producing *Rosa damascena* oil. A limited extent of oil is also produced from *R. gallica* in USSR and Egypt. The third species which is used for oil production in France and Morocco is *Rosa centifolia*.

BOTANY

Rosa damascena is a perennial with a life span up to fifty years. The plants reach a height of 2.5 to 3.0 m. The stems are somewhat arching and are provided with numerous moderately stout and hooked falcate prickles of unequal size, intermixed with numerous unequal aciculi and glandular bristles.

Leaf stipulate, compound, imparipinnate with five to seven leaflets; stipules adnate; leaflets moderately large – 2.5 to 7.5 cm long and 1.5 to 4.0 cm broad, ovate to oblong, glabrous on the upper surface but softly pubescent at the lower end, margin serrate, glandular with fine hairy outgrowths which are also present on the raised midrib of the lower surface; glands brown to red; petiolules also

pubescent and slightly glandular. Inflorescence, corymbose; flowers sweet – scented, red, pink, or white sometimes striped; pedicel possesses densely packed aciculi and hispid glands; bracts more or less lanceolate; sepals reflexed; petals variable in colour, white or red. Gynoecium apocarpous. Fruit ovoid or obovate.

SOIL AND CLIMATE

It grows on a variety of soils, but light and well aerated soils are ideal. The acid soils inhibit plant growth and reduce flower yield. Such soils are therefore neutralised by applications of hydrated lime. It also grows well on alkali – saline soils with pH range of 8 to 8.

Rose is a light – demanding plant and adequate sunshine is essential for its proper growth. The site selected for planting of roses should, therefore, be well exposed to sunshine. The area should have a protection from strong winds. High air humidity (above 60%), combined with moderate temperature (15 – 20°C), are most favourable for obtaining a large rose harvest. Low air humidity not only reduces the content of essential oil in the flowers, but, if accompanied by high temperature, leads to the abscission of some flower buds before they come to blooming. While a mild temperate climate is ideal for it, the plant does well under sub – tropical climate also.

The lengthy spring period with a mean temperature of 5 to 15°C in Bulgaria exerts a decisive effect upon the growth of rose, since these temperature conditions are most favourable for the formation and development of flower buds, for the synthesis of essential oil and for the picking of roses. This prolonged spring in the Valley of Roses with considerable daily temperature amplitudes, is an important factor for the high yields and high quality of the produce obtained.

The peculiar combination of rainfall and temperature in the Valley of Roses leads to higher air humidity (about 70%) during the period of flowering – May and June. The well expressed daily fluctuation of temperature in combination with the higher air humidity leads to the formation of morning dews, the water drops of which cover the rose bushes and their blooming flowers. This bedewing contributes for the higher content of essential oil in the flowers.

PROPAGATION

Rose is propagated vegetatively only as the plants obtained from seed usually have a smaller number of petals.

Practice followed in Bulgaria

i) Old Bulgarian method of propagation : The planting material is obtained from either uprooted or cut to the ground, old, already unprofitable rose bushes. Also 3 – 4 year-old bushes can be used, but most often 8 – 10 year-old ones are cut off when rejuvenation of the rose plantation takes place.

Trenches 35 cm deep and 40 cm wide are dug for the planting of the uprooted or cut off rose bushes. The interrow space is 2.0 to 2.5 m. The bushes are lain down horizontally, consecutively one next to the other on the bottom of the trench, their ends overlapping 10 – 15 cm. The bushes are then covered by a soil over which 5 – 6 cm – deep layer of decomposed manure or decomposed straw is placed. In this way until the first tillage the trench level remains 15 – 20 cm beneath the surface of the interrow space. Planting takes place in November and can be continued till February.

In the spring, after it has warmed up, new shoots develop from the buds of the dug in rose bushes. The rows are weeded by hand till the new shoots emerge from the soil. Later on hand tillage is done along the rows in such a way that the soil from the interrow spaces is gradually pushed down into the rows so that by the end of summer the trenches reach the level of the soil surface.

The rows of a rose plantation thus planted resemble a hedge without fixed space between the individual plants in the row and this is the main defect of this method.

With the planting material obtained from 1 hectare old rose plantation, 2 hectares new rose plantation can be planted in this way.

ii) Propagation by rooted planting material (New method)

a) Preparation of rooted planting material

The cut bushes are lain down in a nursery where regular watering of the young rose plants is ensured. The rooted branches are lain down in the previously described manner, only the distance between the rows is reduced to 150 – 160 cm. If the bushes have thick branches, these are cut at their base and divided into separate pieces, each one, if possible, having both old wood and one year old shoots. The bottom of the trenches in which planting material is placed for rooting is sprinkled by 200 – 300 kg/ha superphosphate. If the planting material is not well developed, two branches can be put parallel in the trench. November is considered as the most favourable time for laying the material to root.

In spring, the buds of the dug in rose bushes develop and produce new shoots. At the beginning the rows of young shoots are weeded by hand and later on cultivated between the plants by a two – pronged hoe. The interrow space is regularly mechanically cultivated in order to preserve soil moisture and eliminate weeds.

Fertilizer application enhances the development of young plants. The first dose of 120 – 150 kg/ha ammonium nitrate is given in the beginning of June; the second, of 150 – 200 kg/ha by the end of July.

Plants are irrigated with small streams of water, with a view to avoid soil washing and uncover of the roots. The number of irrigations depends on the duration of drought. The rows should not be longer than 40 to 50 m to ensure proper irrigation. Sprinkler irrigation gives better results than gravity irrigation.

The rooted planting material is dug out in the autumn of the second year. The young plants are separated from the mother bushes by hand with pruning shears. In case roots have been formed only at the young plant's base the plant is divided from the old branch. Often, however, rootlets develop also on the old branch around the bud from which the shoot springs. In such a case part of the old branch, in the form of a heel, is cut together with the young plant. The plants are then bound in bundles of 25 and kept in loose soil up to the place of branching or entirely, for temporary storage.

b) Preparation of land

As root system reaches a depth of 3 m, the areas on which roses are to be planted are trench ploughed in spring at a depth of 50 to 70 cm, which eliminates also the perennial weeds. 40 – 50 tons stall manure and 1,000 kg superphosphate (P_{10}) per hectare are applied on the area. During the summer as soon as weeds appear, the area is ploughed with a disc plough. Just before rose planting the soil is ploughed again at a depth of 26 – 30 cm.

c) Transplantation

The most favourable time for planting is from last ten days of October till the end of November. Spring planting is not recommended as prolonged droughts occur very often in Bulgaria during the months of March and April and the water deficit leads to unsatisfactory transplantation.

Plants are planted in continuous trenches, 30 – 35 cm deep. Highest yields are obtained from garden planted 2.20 × 0.8 m.

In the field the young roses are planted 5 – 10 cm deeper than they have been in the propagation nursery. The point from where the main branches develop should lie 5 – 6 cm beneath the soil surface and these branches should protrude 5 – 10 cm above it. The soil is preserved closely around the roots. After the field is planted furrows are made on both sides of the rows so as to push soil over the plants and cover them. In this way the whole trench is also filled up. After that by hand the plants are covered with soil up to their tips forming around each single rose a hip of soil, which covers the entire bush.

Practice followed in India

a. Raising of rooted cuttings

The cuttings are obtained from mature plants during the month of January, when pruning of this particular species usually takes place. A 20 x 5 m piece of land is selected for raising nursery plants, which give adequate planting material for one hectare of land. The land should be well – dug and supplied with 400 kg of well – rotten farmyard manure and cuttings, 20 – 25 cm long, are put in nursery beds for rooting. Precallusing of these cuttings by putting them under sand for about 15 days gives better results. A mixture of sand and soil gives better rooting. Planting these cuttings after treatment with either Seradix or IBA gives a higher percentage of success with profuse rooting and better growth. In nursery beds the cuttings are spaced 10 x 30 cm. The beds should be frequently irrigated. Cuttings take about three months to sprout and wellrooted cuttings are fit for transplantation in the field from October onwards. The plants are about 9 – 12 months old by that time.

b. Preparation of land

The land should be ploughed deep during the month of April and left open throughout the summer. In the months of June and July, green manuring by any leguminous crop such as *Sesbania bispinosa* or *Crotalaria juncea* is recommended. Six to eight weeks' old crop should be turned down by soil turning plough and allowed to rot till October. By the end of October, when the rains usually cease, the land should be ploughed again at least 3 – 4 times. In the absence of green manure well – rotted cow – dung manure @ 25 – 30 tonnes per hectare is added to the field as basal dose. After the field is ready, beds of convenient size, say 6 x 4 m, are made for the sake of good irrigation.

c Transplantation of nursery plants

Trenches or deep furrows, about 1 meter deep and 0.5 meter wide, are dug 1 x 1 m apart. The trenches are filled with well – rotted farm – yard manure @ 8,000 – 10,000 kg per hectare. Rooted cuttings are transplanted in the trenches. About 10,000 plants are needed for planting one hectare of land.

The best time for transplanting rooted cuttings ranges between the months of October and December though it can be continued up to February, if proper irrigation facilities are available during summer.

FERTILIZER APPLICATION

It is a soil – exhausting crop. Well – rotted cow – dung or farm – yard manure should be used liberally @ 8 tonnes per hectare, in addition to the use of fertilizers just after pruning. A good crop requires 200 kg of nitrogen per hectare, which should be applied in two equal doses. For soils of high pH, i.e., 8.0 – 9.5, half of this quantity may be applied at the time of pruning and the remaining half a fortnight later. Calcium ammonium nitrate gives the best results. 50 kg of P_2O_5 in the form of superphosphate, per hectare, should be applied around the main stems of the plants, at a depth of 3 – 5 cm just after pruning.

Potassic fertilizers should be applied only when the soil is deficient in this chemical. 20 – 30 kg of K_2O per hectare should be applied as a top dressing around the plants after pruning.

In Bulgaria, 400 kg superphosphate and 150 kg potassium sulfate are applied per hectare of rose plantation in the autumn. The fertilizers are introduced at a depth of 20 and 30 cm aside from the rose bushes, because in this area the greatest part of feeding roots is found. The yield of rose flowers increases by 15 – 20% following a phosphorus application in this manner as compared to application of the fertilizer at a depth of 10 cm. In March, with the first soil cultivation 300 kg/hectare of ammonium nitrate are applied.

INTERCULTURE AND WEED CONTROL

As weeds hamper the normal growth of young plants, the field should be kept free of weeds from the very beginning. Further, thorough weeding and hoeing should be done after pruning every year in the months of January and February.

For hoeing, the earth around the root zone of each plant should be turned well. After hoeing, the field should be irrigated. At least 3 weedings and 5 hoeings are given every year.

Investigations carried out in Bulgaria have shown that the most appropriate herbicides against annual weeds of rose plantations are Simazine and Atrazine. The spraying is done early in spring before the rose bushes have begun to grow, immediately after the cultivation of the plantations. On light soils usually 3 kg/ha of Simazine or Atrazine diluted in 600 -700 l of water are applied but for medium or heavy soils 5 kg are needed. The herbicides do not affect rose oil quality.

IRRIGATION

The plant requires ample water supply and need frequent irrigation during the period of vegetative growth and flowering. In all, 10 – 12 irrigations are required in a year. Irrigation just after pruning is also essential, in order to protect the sprouting buds from withering away due to loss of water or damage by chilling temperature or frost.

Although maximum precipitation in Bulgaria coincides with the appearance of flower buds, the need of irrigation is very great. Besides, precipitation in April, when flower buds are initiated, is usually scarce and therefore, the two irrigations in April and in the beginning of May have favourable effect on the yield of rose flowers, especially if fertilizer application has previously been effected.

PRUNING

For getting higher yield of flowers, plants need pruning. The time of pruning varies from place to place and is to be regulated according to the local conditions. It takes 75 to 90 days after pruning for the plants to flower. Plants are pruned annually or twice or more in a year. In plains, pruning takes place from the middle of October to the middle of December. On the hills pruning takes place after winter, from the beginning of February to middle of March. The plants should be pruned up to a height of 50 cm from the ground level, removing all the shoots and branches, above this height, with the help of shears or secateurs. In addition, dried branches are also removed.

In Bulgaria the most appropriate time for this operation is when the first leaves appear. In this period the unviable and semi – withered branches can be distinguished [illegible] ily and no error could be made in their removal, while at an earlier period many of [illegible] unnoticed on the bushes and later desiccate.

- During the first 2 – 3 years, in rose plantations created from rooted planting material once or twice in the summer the vigorously growing shoots are topped in order to provoke branching and formation of regular, symmetrical crowns, which produce more flowers.

DISEASES AND PESTS

a *Diseases*

Rose rust (Phragmidium subcorticium). The disease attacks the leaves, flowers and shoots of the rose bush and can cause untimely leaf fall, weathering of individual branches and abscission of diseased flower buds. The rose bush is weakened and becomes sensitive to freezing. The losses from rust sometimes amount to 40%.

The disease is controlled by the heaping of soil around the rose bushes by which all fallen leaves are covered with soil and decompose. The winter rust spores also perish because of develop – ment of antagonistic micro – organisms.

The chemical control is effected twice – by autumn or winter spraying and spring or summer spraying

The autumn and winter treatment of rose plantations is done after the last cultivation when soil is heaped around the bushes. Both the rose bushes and the soil under them are sprayed by 1% solution of selinon (dinozol) or by 2% Bordeaux mixture to which herbicide can be added.

The first spraying of the roses against rust is effected at the beginning of April with 0.5% solution of Perozine or even better with a combination of 0.5% solution of Perozine and 0.5% of Tiozole, to which 0.25% Haftol is added as adhesor. The second spraying is made 15 days after the first one, while the third – just before anthesis, using the same chemicals.

The chemical Aspor (Perozine) is equal in effectiveness to the Bordeaux mixture. What is more, a stimulating effect of Aspor has been observed, which is probably due to the content of zinc in this chemical. Flower yields are increased considerably.

Brown rot of roses (Marsonina rosae Trail. *Diplocarpon rosae* A.E.). The leaves attacked by this disease become spotted and fall prematurely, leading to the weakening of the rose bush and to reduction of the yearly growth of shoots. The diseased bushes freeze in case of low winter temperature.

In autumn, when soil is heaped on the roses, the fallen leaves, carriers of infection, are also covered and decompose in the soil and the disease disappears together with them.

In autumn or winter the spraying of rose bushes and the surrounding soil is effected by 1% of selinon (dinozol). The following sprayings are similar to those used in rust control. It has been established that control measures of roses rust eliminate also the agent of brown rust.

Die – back Disease

After pruning, sometimes the cut ends turn black and die. This die-back is caused by the fungus *Diplodia rosarum* Fr. As a preventive measure, cut ends should be treated with a copper fungicide, such as copper sulphate. Partially diseased twigs should be cut away and the cut end of the plant painted with a fungicidal solution.

Rose – Mildew

Often whitish or greyish spots appear on the leaves, which ultimately spread as a thin powdery layer and the affected portions dry up completely. This is the Rose Mildew disease, caused by *Sphaerotheca pannosa* (Wallr.) Lev. var. *rosae* Wor. Application of cycloheximide alone or in combination with sulphur controls the disease.

Black Spot Disease

It is caused by the fungus *Diplocarpon rosae* Wolf and affects the dorsal surface of leaves which ultimately fall off. Spraying with 2:2:50 Bordeaux mixture or Dithiocarbamate is recommended as a control measure.

Chlorosis of leaves

Chlorosis of leaves caused by iron deficiency of soil is quite common and a spray of 0.1 – 0.2% ferric sulphate solution is recommended to control it.

b. Pests

Agrillus of the oil – bearing rose (Agrillus mokrzeckii (Obubr.), is the most dangerous pest for this crop. It inflicts yearly considerable damage on rose plantations as a result of which flower yield sharply decreases. The larvae also cause damage. They screw spiral openings into the wood of the branches where a spindle – shaped swelling appears. The infested branches wither above the damaged sector and desiccate until the end of summer.

The control of agrillus is carried out by combined mechanical and chemical means. In spring, at the end of March and the beginning of April, all infested branches are cut off 8 – 10 cm below the swelling, taken out of the rose plantations and burnt up.

It has been established that in case of proper agro – technical measures the infestation of rose plantations by agrillus is considerably less while in neglected rose plantations infestation by this parasite spreads more widely. Chemical controls is conducted both at the time the insects fly and at the time they lay eggs.

The chemical Volatox 0.20 – 0.25%, Phonition and Thiofenit 0.4 – 0.5% are most effective.

Beginning in the first ten days of June, two to three sprayings are effected at intervals of 10 to 12 days. To improve the solution's adhesiveness some 0.25% haftol is added.

The rose sawfly (Platyptillia rhododactyla F.) is another pest of rose. The caterpillars feed on rose flower's petals. Chemicals of the thiophosphorus group are used for its extermination.

The rose snout beetle (Rhynchites hungaricus Hrbs.) hatches its eggs in the flower buds, then it gnaws through the bud peduncle which falls on the soil. Thiophosphorus containing chemicals are used for protection against this pest.

The rose scale (Physokermes bulgariensis Wilm.) sucks the sap of the branches, while the larva – of the leaves and young rose shoots. The infested plants weaken and remain underdeveloped, flower yields are greatly reduced and the rose bushes perish. In the control of this pest Selinon (dinozol) and some other chemicals are used during the dormancy period of the rose and thiophosphorus containing chemicals during vegetation.

The rose cycad (Typhocyba rosae L.) sucks sap from the back side of the leaves and as a result the later grow pale and fall. Thiophosphorus chemicals are used for the control of this pest.

The rose aphid (Macrosiphum rosae L.) attacks the leaves, the flower peduncles and the rose bush tips. Thiophosphorus chemicals are used for protection.

White ants : These very often pose a serious problem, damaging young plants in the field. To control them, the soil should be treated with endrin or chlordane.

HARVESTING

In Bulgaria, the first harvest is obtained in the third year. Flowering begins in the 2nd half of May and continues for 3 or 4 weeks. Date and duration of the crop depends upon the weather prevailing in a particular period. Harvesting starts at the daybreak and ceases, if possible, at eight or nine in the morning while the dew is still fresh on the flowers.

Work carried out in Bulgaria has shown that rose flowers have maximum oil from 5 to 9 a.m. and this is the time at which the flowers should be picked up. The content of essential oil in flowers picked from 9 to 12 o'clock is 30 – 40% less than that in flowers picked at 7 a.m. In the afternoon oil content continues to diminish and at 8 p.m. it is 70% less than in the flowers picked at 7 a.m.

In India, the total flowering period is about 40 – 45 days, after which the yield declines and is practically over by the middle of April. Sporadic flowering may continue almost throughout the year.

Harvesting is done as quick as possible, as the time of gathering has much effect on the yield of oil. The flowers are transferred for distillation as early as possible to avoid deterioration in quality.

YIELD OF FLOWERS

As mentioned earlier, the first harvest in Bulgaria is obtained in third year of planting. However, the yield is poor and amounts to about 1,500 kg/ha. From 4th year onwards, the yield increases reaching about 5,000 kg/ha at the peak of productivity. On the average, a well – kept rose field yields about 2,000 – 3,000 kg of flowers/ha/year.

The hot and dry weather shortens the harvest period, resulting in decreased yields. Decrease in the humidity and increase in the soil temperature affect the flowering buds adversely. The yield of flowers is also affected by age.

Temperatures ranging from 0 to 5°C for a period of about 15 days prior to the start of blooming greatly enhances the quality and quantity of flowers. At the time of flowering the temperatures should be between 25 and 30°C and the relative humidity 60%.

Sometimes there is a great fall in the flower buds before they start blooming. In dropping buds, chlorophyll, xanthophyll and carotine are less than those present in healthy ones, while NPK are more but Ca and Na less in healthy buds in comparison to the dropping ones. Application of mixed fertilizers along with organic manures reduces the fall of buds by 20% when irrigation follows application; when no irrigation is given, decrease is only 17%. When the irrigation is delayed after fertilizer application, the fall is checked only by 14%.

REJUVENATION

It is observed in Bulgaria that in the first 5 – 6 years following planting yields are rising but after this they begin to fall and after 8 – 10 years the roses become unprofitable to grow. This imposes the rejuvenation of the rose bushes. Autumn is the most favourable time for this operation. The bushes are cut down to the base. After that, on both sides of the row furrows 18 – 20 cm deep are opened, the soil being heaped towards the interrow space. In these 30 – 50 tons of manure and 400 – 500 kg of superphosphate per hectare are placed and then covered up again with soil. In the spring new shoots develop from the roots. In this way the rose bushes are rejuvenated and the yields rise.

EXTRACTION

Rose perfume is extracted from the flowers by distillation or by extraction with volatile solvents.

DISTILLATION

Distillation is carried out in steam stills. The flowers are covered with water and they should move freely in it. Distillation should be started more carefully and slowly. Time of distillation depends upon the capacity of the still. The inlet for cooling water in the condensers is regulated so that the condensate flows at a temperature between 35 – 45°C. At lower temperatures, a stereoptene present in the oil solidifies in the condenser tubes. The volume of water distilling over should be just sufficient to carry out the oil and not excess. Too much aqueous distillation washes out the oil separating in the separator and redissolves some of its constituents. If the distillation of the flower is delayed, they can be stored in clean coldwater for a period of 3 days without any loss in oil content and change of oil quality. Only 20% of the oil is obtained in first distillation and all the distillate is passed through a cohobation chamber in order to get the rest of oil.

Rose Concrete

Fresh flowers are treated with high refined petroleum ether. The extract so obtained is called rose concrete. It is obtained in a yield of 0.15%. However, yield to the extent of 0.25% is obtained in the case of *R. centifolia*. It is brown to dark – brown waxy mass with a characteristic rose odour.

Rose Absolute

This is an alcohol soluble portion from concrete and is free from waxes. It is obtained in a yield of 50% and contains 35-42% of steam volatile oil. This absolute is a viscous greenish brown liquid. Its odour is strong and characteristic of rose, but softer, more mellow and durable than the distilled oil.

OIL YIELD AND OIL CONTENT

The yield and quality of oil depend upon various factors, such as soil and climate, season of harvest, time of plucking the flowers during the day, condition of flowers used, e.g., fresh or pre-treated type of still used, etc.

Mild and humid weather increases the yield of oil and also give good quality oil. Yield of oil is lowered during very hot and dry weather because of evaporation of oil. When large quantities of roses arrive at the distillation, these cannot be processed immediately and are thus left on the field for hours. This results in fermentation of flowers and thus the aroma suffers. Flowers plucked early in the morning produce more otto of a finer aroma than those picked at noon or afternoon.

Yields varying from 0.02 to 0.025 have been obtained in India. In Bulgaria the yield of oil is 0.02 to 0.03%.

CHEMICAL COMPOSITION AND USES

Bulgarian Rose

Major constituents of Bulgarian rose oil are rhodinol (1-citronellol) and geraniol. The following table gives the relative proportion of major constituents of Bulgarian rose oil:

Major constituents of Rose oil

Rhodinol (1-citronellol)	38%	(33-51%)
Paraffins	16%	
Geraniol	14%	
Nerol	7%	
β-Phenyl ethanol	3%	
Eugenol methyl ether	3%	

Linalool	2%
Ethanol	2%
Farnesol	1%
	86%

Today about 275 compounds have been identified in Bulgarian rose oil. Out of these, seven compounds constitute the rose fragrance and form about 1% of the essential oil. They are:

- β-Damascenone
- β-Damascone
- β-Ionone
- ρ-Menth-1-en-9-ol
- Nerol oxide
- Rose furan
- Rose oxide

Rose oxide and nerol oxide contribute to the geranium-like odour; rose furan and menthenol derivatives develop a characteristic citrus note; β-ionone reproduce the typical scent of violets, β-damascone has an odour related to β-damascenone which possesses narcotic scent.

Oil of rose is one of the oldest and most valuable perfumery raw material. Rose oil imparts characteristic flowery top notes to perfumes. The extracted absolute adds lasting tonalities and increases fixation of odours. A mixture of distilled oil and extracted absolute combines the advantages of the two products. The distilled oil is employed in cases where solubility in dilute alcohol is important. The absolute is soluble only in high-proof alcohol and can therefore be used only in handkerchief perfumes or in cosmetics where solubility plays no role. In powders and cream even the lower priced concrete give excellent results.

Bulgarian rose oil is used for flavouring of certain types of tobacco, particularly snuff and chewing tobaccos and in a number of fruit flavours. Limited quantities of otto are employed in flavouring soft drinks and alcoholic liquors.

Roots of *Vetiveria zizanioides* (Vetiver)

OIL OF VETIVER

INTRODUCTION

Roots of the grass *Vetiveria zizanioides* (Linn.) Nash on distillation yield an essential oil called vetiver oil. Two types of grasses are known : one growing wild and the other being cultivated. The wild variety is found throughout the plains and lower hills of India, Burma and Ceylon up to 1,200 m. The cultivated variety grows in southern India, Java, Malaya States, Philippines, Japan, Reunion Island, Angola, the Belgian Congo, Haiti, the Dominican Republic, Brazil, Argentina, British Gulana, Jamaica, Mauritus and Martinique. It is also cultivated in Honduras and Guatemala. Haiti and Reunion are the largest producers of the oil.

BOTANY

Culms stout, up to and over 2 m tall, form an aromatic rhizome, usually sheathed all along. Leaf blades linear, acute, 30 – 90 cm long, 4 – 20 mm wide, erect, rigid, firm or somewhat spongy, usually glabrous, rarely more or less hairy downwards on the upper surface, pale green; midrib slender, lateral nerves close; sheaths compressed, particularly the lower, which are sharply keeled, equitant,

imbricate, very smooth, firm; ligules reduced to a scarious rim. Panicle oblong, up to over 30 cm long, usually contracted; rachis stout, smooth; whorls of branches 6 – 10 with up to 20 rays; branches oblique to sub – erect, filiform, slightly rough. Racemes 5, rarely 12 cm long, very slender; joints about as long as the sessile spikelets or sometimes distinctly exceeding them in length; smooth, or more or less rough, minutely and unequally ciliate at the slightly oblique tips; pedicels smaller but shorter. Sessile spikelets linear – lanceolate to almost linear acute or sub – acute, 4 – 4.5 mm long, yellowish, olive, violet – brown or purplish to almost black, callus obtuse, less than 1 mm long, glabrous. Glumes acute, coriaceous; lower muriculate all over the back, 5 nerved, lateral nerves close, very fine upper glume spinulosely muricate on the keel. Lemma of the lower floret as long as the glumes, acute, retrosely ciliate; upper floret hermaphorodite; lemma up to 3 mm long, narrow, oblong, lanceolate, mucronulate, eciliate. Anthers 2 – 3 mm long. Pedicelled spikelet sparingly aculeolate or almost smooth; lemma of upper floret entire, acute.

The length of the root varies from 10 to 35 cm according to the conditions of growth soil, climate, etc. of the locality.

In the genus *Vetiveria*, spikelets occur in pairs, each pair consisting of a pedicellate and a sessile spikelet. The sessile spikelet normally includes a hermaphorodite floret, while the pedicellate spikelet has always been reported to contain a male floret. The occurrence of a clone having perfect florets in nearly all the pedicellate spikelets has been reported.

Vetiveria zizanioides – Single plant

Vetiveria zizanioides – Field view

WILD VARIETY (NORTH INDIAN VARIETY)

In North India, the variety grows wild, specially in the forests of Rajasthan and Uttar Pradesh and seldom cultivated. The tillering habit of the grass and scattering of the seeds due to winds have resulted in large scale natural propagation of the same. It is a moisture – loving plant and therefore grows best on low, swampy soils.

In North India, the harvesting of roots commences from November to February. Stems are cut at the ground level leaving the roots and clums in the ground.

The moist areas are taken up first. The waterlogged areas become dry enough in February for digging of the roots. No digging is done after February, as with the rising temperature the soil becomes harder, which makes digging very difficult. The roots are dug by a one – edged pick – axe (Kudali). A few sturdy strokes with the pick – axe all round the clump loosen the roots and the major part of the clump is uprooted with clods of earth. These clods of earth are separated from the roots by beating with a hoe handle. The roots are then bundled and brought to the distillation centre.

The method of extraction of roots at present is not efficient as large number of roots are left underground. Thus the recovery of the roots is less. However, this method has one great advantage that the left slips with roots regenerate and grow within two years sufficiently thick in size for extraction.

Yield

A hectare of khus growing area is estimated to yield 2.7 to 3.7 tonnes of freshly cut roots. This yield depends on the growth of the roots, which in turn, depends on the amount of the rainfall in the preceeding monsoon, the winter rainfall, the moisture retaining capacity of the soil, the time of exploitation and the age of the crop.

Distillation

The distillation of khus roots is generally done in the country stills at the centres. There are only few factories in Uttar Pradesh (India) which manufacture khus oil using steam. The oil extracted by steam distillation is almost 20 to 25% more than by country stills. Soaking the roots in water before distillation increases the oil yield.

The distillation of vetiver oil offers considerable difficulties on account of its constituents possessing high boiling point and comparatively low volatility with steam. The most valuable constituents of vetiver oil are contained in the high boiling fractions; to capture these roots have to be distilled for many hours. Further its density being close to that of water and its high viscosity are responsible for the difficulty in separation of the oil from water.

Oil content and oil yield

Yield of the oil from vetiver roots depends upon various factors, e.g., the soil, climate, frequent cutting of the grass, time of lifting the roots, treatment of the roots preliminary to distillation, method of distillation and recovery of the oil, time of distillation, etc. The yield varies from 0.1 to 0.3%.

Pests and disease

No serious pests and diseases have been reported. *Gloeocercospora sorghi* Bain & Egerton infects leaves. On infested leaves, the fungus appears as diffused brown leaf spots with irregular margins.

CULTIVATED VARIETY

Soil and climate

Although vetiver grows in almost every type of soil, but a rich and fairly well – drained sandy loam is considered the best. The grass grows luxuriantly in the place with an annual rainfall of about 1,000 to 2,000 mm, temperature ranging from 70 to 100°F and with a moderately humid climate. Shady areas should be avoided.

Preparation of land

The land is ploughed and harrowed so as to give a fine tilth. Most of the grasses and stumbles are removed so as to avoid weeds completely.

Cultivation

The grassy tops are cut off to within 15 to 23 cm of the root. Most of the fine, hairy root system is separated and set aside for distillation, but some of the fine roots are left on the stock which are divided for replanting. Planting stock should be kept in the shade till the root divisions are planted in the fields, but exposure to the sunlight for a few days will do no harm as the plants are actually quite hardy; planting stock should be covered with the grass tips till they are planted.

Planting takes place in the rainy season. If facilities for irrigation are available, planting may be done in January and February.

Slips are planted in holes, 5 to 8 cm deep. The soil around the slips is pressed firmly and levelled. Three to four slips are planted in each hole when slips are readily available on the spot to provide for failures and to obtain a thick stand. In the case of first planting, when slips have to be purchased and transported over long distance, 1 to 2 slips are planted in each hole. From an average sized clump about 20 to 30 healthy and suitable slips can be obtained. Plants are spaced between 60 cm and 90 cm.

Fertilizer application

In fertile soils no fertilizers are necessary and normally vetiver fields are not fertilized. However, to get a good crop, it is better to apply 30 kg P_2O_5 and 30 kg K_2O as basal dose per ha. Sixty kg per ha of nitrogen is applied as a top dressing in two equal doses in the first year of planting.

Weeding and interculture

Weeding the area and earthing – up the plants are essential. Three to four weedings are necessary in the first year and two to three in the second year as the crop is kept in the field for about 18 months. In the second year, one of the weedings is done just before harvest to facilitate the harvesting and avoid any root of weeds getting mixed with roots of the crop.

Irrigation

In places where long periods of drought are there, 2 – 3 irrigations are necessary during the rain – free period.

HARVESTING

Harvesting of roots varies from place to place. In some countries they are harvested after 2 years of growth, whereas in other after 16 months. The growth period is between 18 to 24 months.

If a fully developed root system and a high quality of oil are desired, the root should not be extracted from the ground earlier than 15 months after planting. Young roots are tender, thin, almost hairlike; on pulling they break easily and stay in the ground. Furthermore, on distillation they yield an essential oil with a low specific gravity and low optical rotation. The odour of these 'light' oils is 'green', 'earthy'. Older, more developed, somewhat thicker root, yields an oil of better quality and its optical rotation and specific gravity are higher, the odour fuller, richer, more lasting. Oils derived from older roots are usually of darker colour than the oils distilled from younger roots.

The harvesting is done with digging forks of 45 cm length. The stem portion is cut at a height of 15 to 20 cm and the clumps are uprooted. About 50 to 60% of the roots come away with the clump leaving the rest in the soil. The clumps are beaten on a piece of log to remove stones and earth adhering to the roots and the roots are separated with a sharp knife. As far as possible, the roots left in the soil are also collected.

Washing

The harvested roots contain large quantities of earth sticking to them. If the earth is not removed, an oil with an undesirable note and poor colour results when distilled. Immediately after harvest, therefore, the roots are washed in clean running water to remove the adhering earth.

Drying

The cleaned roots are spread on drying grounds made of bricks. The root is turned over at regular intervals until dry and any foreign matter is removed. The cleaned and dried roots are sent to distillery or storage shed where they are allowed to mature.

Drying in the shade for 1 – 2 days improves the olfactory quality of the essential oil, while prolonged drying in the sun reduces the yield.

Yield

The age, the soil and climatic conditions are important factors governing the yield of roots. In India, a yield between 4 – 7.5 tonnes of fresh root has been reported. In Java and Brazil one hectare yields about 1,000 – 1,300 kg of air – dried root.

Distillation

Freshly harvested roots on distillation give a higher yield of oil (1.50% on zero moisture basis) than stored roots, the yield decreasing progressively with the period of storage (1.44% for roots stored for 15 days, 0.98% from roots stored for 60 days and 0.79% when roots stored for 120 days). Further the release of oil is much lower in stored roots and therefore such roots call for a longer period of distillation for completely exhausting them than freshly harvested roots. Therefore to obtain maximum yield of oil and reduce the time of distillation, the roots should be distilled when fresh. Fresh roots again easily cut into bits for distillation than stored roots. The oil extracted from both types of roots satisfies the accepted standards, but oil obtained from stored roots is more viscous and possesses a slightly better aroma than that obtained from freshly harvested roots.

To render the root material soft and thereby further facilitate release of oil, the roots are soaked in water prior to distillation, the optimum period for which the roots are soaked is 17 to 20 hours. Soaking for shorter period does not bring about the desired effect. Soaking for longer periods sometime causes the material to rot and such material gives a poor quality of oil. From soaked roots, oil yield of 1.70% has been obtained, whereas from unsoaked roots, oil yield of 1.48% (both on zero moisture basis) has been obtained.

To obtain the maximum yield of oil and facilitate quick release of oil the roots are first chopped into small bits. Chopping them has an additional advantage, in that, a large quantity of roots can be packed into a still. Fresh roots cut to lengths of 2.5 cm to 5 cm yield 1.71% of oil; when roots cut to lengths of 5 cm to 10 cm, oil yield is 1.40% (both on zero moisture basis).

In modern apparatus where stills are made of stainless steel or aluminium sheets and which work at 10 to 12 atmosphere of pressure, 12 to 16 hours are sufficient to complete the distillation. The stills are well insulated. A series of large tanks are used as oil separators. The combined fractions of the oil are filtered warm in steam – jacketted filters and some producers use small centrifuges for the purpose.

OIL CONTENT AND OIL YIELD

The oil yield of vetiver roots varies considerably and it depends on a number of factors such as degree of dryness of the roots, age of roots, nature of the land under cultivation, lifting time, perfection of the distilling equipment, etc. The average yield is between 1.5 to 2.00%.

Under the South Indian conditions, an average yield of 12 to 15 kg of oil per hectare can be expected, even though the yields as high as 20 to 22 kg are reported to be common.

Aging

Aging for a period of six months improves the odour of the oil substantially; the 'harsh', 'green' and 'earthy odour' characteristic of the freshly distilled oil will disappear and develop into a fuller, heavier and sweeter odour.

Diseases

Curvularia trifolii (Kauf.) attacks vetiver, causing leaf blight. Tan to dark spots, oval in shape,

appear which later turn black, while the rest of the affected leaves become pale yellow and finally dry up. Repeated spraying of copper fungicide (0.3%) containing 50% metallic copper, at the rate of 560 – 830 litres, has been found to control the disease.

CHEMICAL COMPOSITION AND USES

Table -I summarizes relative amounts of major alcohols and ketones in Khusimol area of vetiver oils of different origins. Table – II gives the composition of significant minor components of seven vetiver oils :

TABLE – I

Percentage composition of Khusimol – Vetivones

Origin	Khusimol	Unknown + β – vetivone	α – vetivone	Unknown ketone
	%	%	%	%
Haiti	13.4	5.2	3.2	5.3
Reunion	21.5	3.2	5.8	10.5
Angola (Reunion type)	21.8	4.2	4.7	14.8
Angola	27.9	4.6	5.1	15.3
Guatemala	21.4	2.6	1.5	1.1
China	20.0	4.1	5.2	7.3
Brazil	21.7	4.6	4.9	14.7
Java	13.6	2.8	4.0	7.1

TABLE – II

Selective alcohols, percentage composition in vetiver oils

	Elemol	10 – Epieu – desmol	Unknown	Beta Eudesmol	Veti – verol + Cyclo – copa – camph – enol	Veti – seli – nenol
Haitian	2.3	2.2	4.2	5.5	6.6	11.2
Brazilian	1.6	1.6	4.3	6.6	6.9	11.2
Chinese (1975)	0.8	1.6	3.0	6.5	6.2	13.9
Chinese (1976)	0.8	1.5	2.0	6.5	6.8	19.5
Angola Extra	1.7	1.1	1.3	6.9	7.5	13.6
Angola Reunion	1.7	2.0	2.4	6.0	7.0	11.0
Guatemala	0.4	–	5.5	7.5	6.7	11.8
Java	0.7	1.8	3.5	7.0	6.1	10.3
Reunion	0.7	1.2	3.7	8.4	6.8	11.1
	60 hydrocarbons have been identified					

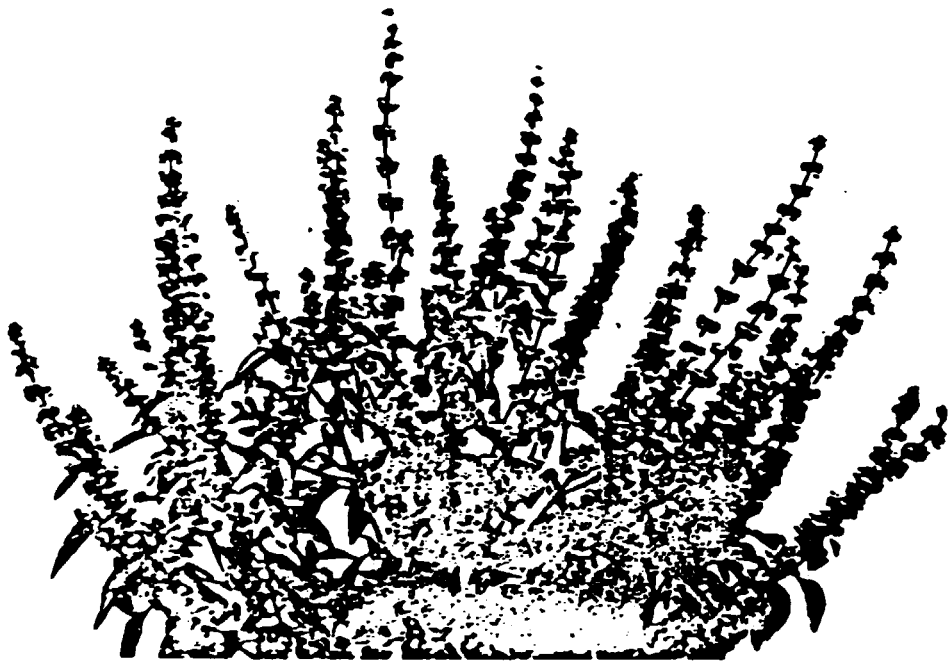
The oil is used extensively in perfumery as a fixative and also as an odour contributor in base as rose basis, etc. The oil also serves for the isolation of vetiverol and vetiverone, the former again being used to produce vetiveryl acetate. Haiti, Reunion and Congo and South Indian vetiver oils are usually

considered best for the isolation of vetiverol. North Indian and Angola oils often have a very high content of vetiveryl esters in their natural state.

Young leaves are used as fodder and considered a good bedding for horses and cattle. Leaves are also used for thatching purposes; stems and inflorescence peduncles are used for making brooms and ornamental baskets. The roots woven into screens, mats, fans, etc. mitigate heat during summer; these retain their delightful fragrance for years specially when sprinkled with water. Infusion of the root is a refreshing drink in fevers, inflammations and irritability of the stomach. Externally a paste of root is rubbed on the skin to remove oppressive heat or burning of the body. Its oil is given in minimum doses to check the vomiting of cholera. Grass used in the form of cigarettes and smoked with benzoin relieves headache.

Pulps suitable for straw boards can be prepared by digestion with lime.

Writing and printing papers can be made from a furnish containing a mixture of *Vetiveria zizanioides* pulp and a long – fibered pulp of sabai grass *"Eulaliopsis binata"* Because of its fibrous root system, it is planted on bounds and contours to prevent soil erosion.



Flowering plant of *Ocimum basilicum* (Sweet Basil)

. OIL OF SWEET BASIL

INTRODUCTION

The basils are fragrant herbs or small shrubs belonging to the genus *Ocimum* comprising about 150 species and growing in warm temperate and tropical regions. Basils found use chiefly in culinary. They are also used for ornamental purposes. They are also source of essential oils which are used extensively as flavours and in food and pharmaceutical industries. The essential oils are also sources of important isolates such as, linalool, linalyl acetate, thymol and geraniol, etc. *Ocimums* are annuals or short lived perennials. They are bushy plants. Although several species of *Ocimum* have been cultivated to a limited extent, Sweet French Basil, *Ocimum basilicum* Linn., is the most important species as a source of essential oil.

It is known to have been cultivated for at least three thousand years by Europeans and Asians for folklore and religious rituals and got established wherever they migrated with extreme variation of its progeny. However, owing to a high degree of polymorphism exhibited by the species, as also abundant cross-pollination, a large number of sub-species, varieties and forms or strains have come into existence which make the botanical nomenclature extremely difficult. Thus, several names have been assigned to the same varieties and even to some of the lesser understood varieties and forms of other species. In view of the great diversity, the various species and varieties have been classified, in accordance with their chemical composition and geographical source, into 4 major types as under:

I. European or Sweet Basil

It is distilled in France, Italy, Bulgaria, Egypt, Hungary, South Africa and occasionally the United States. The oil contains approximately equal proportions of methyl chavicol and linalool.

II. Reunion Basil

It is distilled in the Comoro Islands, Malagasy Republic, Thailand and occasionally in the Seychelles. It is rich in methyl eugenol.

III. Methyl Cinnamate Basil

It is distilled in various tropical countries including India, Haiti, Guatemala and a few African countries. It is rich in methyl cinnamate.

IV. Eugenol Basil

It is distilled in the USSR and some North African countries including Egypt and Morocco. It is an oil rich in eugenol.

Recently *Ocimum gratissimum* L. has been cultivated in USSR mainly a source of eugenol.

BOTANY

Ocimum basilicum Linn. occurring in nature as a tetraploid (2n = 48), belongs to the family Labiatae. It is an erect, almost glabrous herb, reaching a height of 30-90 cm and cultivated in major parts of the country. The plant has many oil glands which impart it a characteristic aromatic odour. Leaves ovate-lanceolate, 3.75-5 cm long; entire or dentate, adaxial and abaxial surfaces glabrous, glandular; petioles very slender, usually slightly hairy; flowers 0.72-1.25 cm long, borne in long terminal racemose inflorescences, simple or much branched, often thyrsoid, bracts stalked, ovate, minute, caducous; calyx 5-toothed, upper tooth rounded, shorter than others, 2 lower teeth ovate-lanceolate with a bristle point, 2 lateral shorter than the lower, calyx partly grown together with bracts, enlarges itself postflorally and remains with the latter dry on plant; corolla 0.72-1.25 cm long, white, pink or pale-purplish, 2-lipped, tube short, upper lip nearly equally 4-lobed, lower lip curved down, not lobed; stamens 4, protruding, twice as long as corolla, bent, hairy at bend; ovary bicarpellary, syncarpous, bilocular, becoming tetralocular later; stigma bifid; fruits nutlets, 4, ellipsoid, dark brown to nearly black, oblong with rounded ends minutely dotted, convex on one side and flattened on the other, surface pitted, varying in size from 2.0-2.9 mm in length by 1.2-1.9 mm in width, mucilaginous covering from heavy to scant, swell in water within 10 minutes with no further swelling after 3 hours.

SOIL AND CLIMATE

The plant does best on moderately fertile well-drained loamy or sandy-loam soils. The clayey or sandy soils are unsuitable for its cultivation. The waterlogged lands should be avoided.

The plant is rather susceptible to frost. The crop growth is adversely affected in areas which receive heavy and continuous rainfall.

PREPARATION OF LAND

The field should be disc ploughed once (if necessary), followed by two cross harrowings and one planking. The soil need not be prepared to a fine tilth but any stubbles of the previous crop should be removed. Convenient sized beds, which may be 15 × 15 m, are laid out with proper provision for irrigation as well as interculture operations.

PROPAGATION

The crop is raised through seeds. The usual practice is to raise the seedlings in the nursery first and then transplant them in the field.

(a) Raising of Nursery

The location of nursery should ensure adequate irrigation facilities. The land is cleared of stubbles, weeds and soil worked well up to 30 cm in depth. Well-rotted farmyard manure and leaf-mould each at the rate of 1 kg per sq m, is applied and the soil is very well pulverised so as not to leave any clod. Beds of convenient size, i.e. 1 × 4 m, with irrigation channels are laid out. Nursery beds of small size facilitates removal of weeds without entering the beds.

As the seeds are minute, they should be mixed with fine sand or woodash to ensure even distribution in the seed-beds. About 125 g seeds are required to give sufficient seedlings for 1 hectare.

The seeds may be sown in lines, about 6 cm apart, or broadcast over the beds and covered with thin layer of sand and farmyard manure. Care is taken to avoid deep sowing which adversely affects the germination. The germination of seeds starts 3 days after sowing and it is over in about 10 days. It is advisable to cover the seed-beds with straw so as to conserve moisture. The straw may be removed when the seedlings emerge. In dry months, it may be necessary to water seedlings twice a day. The nursery is kept clear of the weeds. The seedlings, when 6-10 cm tall, are dug up for transplanting in the field.

(b) Transplanting

The field, at the time of planting must have good tilth. If the transplanting takes place in dry months, the seedlings are covered with moist gunny cloth, hessian or green leaves, soon after their removal from the nursery. This protects them from strong sun, especially on bright sunny days. The transplanting in such conditions is towards the evening and the field irrigated liberally thereafter. Cloudy weather and fine drizzle are ideal for transplanting.

It is recommended to transplant the seedlings 40 cm apart, in rows, 60 cm apart.

FERTILIZER APPLICATION

For economic yield of crop, supply of nutrients is essential. It is advisable to apply 20 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare, as basal dose, before planting. About 40 kg of Nitrogen is also applied as top dressing, in two equal split doses.

INTERCULTURE

The first weeding is given about one month after planting as at the time the seedlings have established well in the field. The second weeding-cum-hoeing may be necessary after another 4 weeks and thereafter, the plants become bushy and suppress the weeds. Earthing of the plants if preferable. Expenditure on weeding may be considerably minimised in large plantations through the use of cultivator drawn by tractor.

IRRIGATION

When raised as a summer crop, irrigation is required once a week. With the onset of rainy season the rains meet the water requirements of the crop fully till September. Thereafter, irrigation may be required once or twice a month.

PESTS AND DISEASES

Only a few diseases and pests have been found affecting the sweet basil plant. These are:

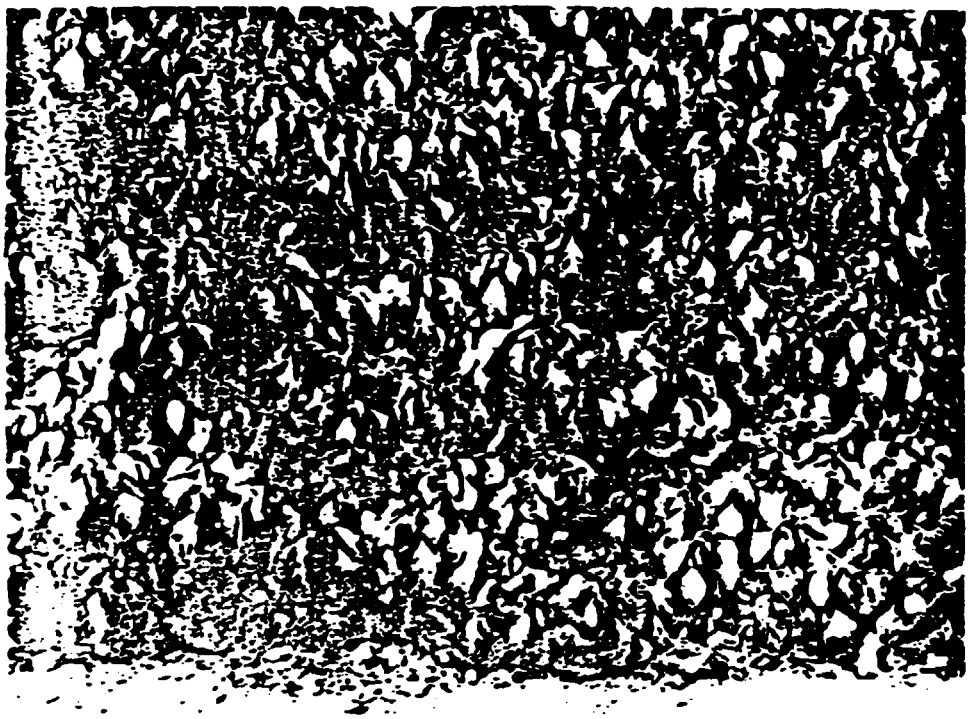
(i) Blight of basil caused by *Alternaria* sp.

It affects the aerial parts of the plant. The disease starts with a chlorotic appearance of the leaves which turn purple and finally black. Ultimately, the leaf-shedding takes place.

Control: It is recommended to spray the crop with 0.2% zineb or mancozeb, once or 2-3 times. The diseased plants must invariably be carefully pulled out from the field and burnt so as to save healthy plants from infection.

(ii) Leaf blight caused by *Collectotrichum capsici* (Syd.) Butler & Bisby.

The disease appears as small chlorotic spots on the leaves which enlarge rapidly, coalesce and turn brown. Abundant acervuli are produced on the leaf surface. Older leaves appear to be more susceptible to infection.



Plantation of *Ocimum basilicum* (Sweet Basil)

(iii) Basil wilt caused by *Fusarium oxysporum* Schlecht. *ex* Fr.

The disease affects the plant at all stages of growth, particularly in the rainy season. The disease appears initially by wilting of leaves and shoot tips on one or two branches, but spreads soon to the whole plant. The plant finally dies.

Control: Before transplanting, the seedlings should be dipped in a solution of some effective fungicide, such as 2-methoxyethylmercury chloride, etc.

(iv) Insect pests/leaf rollers.

Larvae of the pest cause serious damage to the plants by sticking to the undersurface of the leaves, folding them from midrib lengthwise and webbing them. The infected leaves finally fall off.

Control: It is recommended to spray the affected plants with malathion or endosulfan, diluted with water as required.

HARVESTING AND YIELD

The crop is harvested when the plant is in full bloom and lower leaves start turning yellowish. Harvesting is done with the help of hand sickles. The crop may come to full bloom 8-12 weeks after planting. Corresponding to the part harvested, two grades of oil are obtained, i.e., flower oil and herb oil. The oil produced from flowers alone has a superior note and fetches a higher price. For obtaining high quality of oil, only the flowering tops are harvested.

Depending upon the place of cultivation, 4-5 crops are obtained. In some areas it is possible to get four floral harvest. The first is taken when the plants are in full bloom and the second as well as the subsequent harvests after every 15-20 days thereafter. The last harvest comprises the plant as a whole. In some areas three harvests only are taken and the whole plant is harvested. The first harvest takes place 12 weeks after planting and two more at an interval of two months each. It is estimated that floral harvests mentioned above give about 3-4 tonnes of flowers and the final harvest of the

whole plant about 13-14 tonnes of herbage per hectare. About 18-12 tonnes of herbage is obtained per hectare from three harvests. While harvesting the whole herb, care must be exercised to cut the individual plants not less than 15 cm from the ground so that effective regeneration of the crop takes place. If the plants are cut too close to the ground, they may die altogether or produce rather poor crop.

On an average, the young inflorescence contains about 0.4% oil and the whole herb 0.10 to 0.25%. In actual practice, a yield of about 30-35 kg of flower oil and 18-22 kg of whole herb oil, is obtained. If only whole herb is harvested and distilled, the yield of oil per hectare may be about 30 kg.

After the crop is harvested, it is advisable to allow it to wilt in the field for 4 – 5 hours so as to reduce the moisture in the herb. This helps reducing the herbage somewhat in bulk and facilitates its easy packing in distillation tubs. The herbage should, however, not be exposed to sun for prolonged drying as it adversely affects the quality of oil. It may be pointed out here that both the yield of herb and percentage of oil contained therein may vary greatly depending directly upon the fertility of soil as well as seasonal conditions. Further, the more bushy types of plants, with not too many large stems, yield more oil as the oil resides chiefly in the flowers and leaves. Also, bright sunny weather, immediately preceeding the harvest, increases the oil while cloudy or rainy weather decreases it.

DISTILLATION

The oil of sweet basil is obtained on distillation of young inflorescences and/or whole herb by both hydrodistillation and steam distillation. The latter is better than the former as it takes less time and effects better recovery of oil contained in herb. While the former, carried on in a direct fire still, is cheaper and more handy for small plantations, the latter is preferred for large plantations.

In steam distillation, about 1 – 1½ hours are required to exhaust a charge completely. After the oil has been separated from the distillation water, it is advisable to re – distill the latter to recover small amount of oil held in suspension. This may be done in a separate distillation tub or in the same tub after the main charge has been distilled. It is most important that the distillation equipment must be clean before the distillation is started, otherwise the quality of the oil is affected imparting it a disagreeable odour and/or sometimes undesirable colour.

CHEMICAL COMPOSITION AND USES

The chief constituents are linalool and methyl chavicol. Conan examined the chemical com – position of Basil oils and presented a comparison of oils of different origin :

Compound	S. African oil	French oil	Egyptian oil
1	2	3	4
α – Pinene	0.30	0.11	0.25
Camphene	0.07	0.02	0.07
β – Pinene	0.38	0.07	0.43
Myrcene	0.32	0.13	0.35
Limonene	4.94	2.04	4.73
cis – Ocimene	0.11	0.03	0.63
ρ – Cymene	–	0.05	0.10
cis – 3 – Hexenol	–	0.06	0.08
Fenchyl acetate	0.11	0.55	0.09
Camphor	0.75	1.43	0.57
Linalool	54.37	40.72	45.55
Fenchyl alcohol	6.29	6.70	5.52
Methyl chavicol	2.38	23.79	26.56
α – Terpineol	0.83	1.90	1.09
Citronellol	2.77	3.57	1.76
Geraniol	0.19	0.38	0.20
Methyl cinnamate	0.34	0.34	0.25
Eugenol	12.19	5.90	5.90

The oil is extensively employed in several European countries and USA for flavouring of foodstuffs, confectionery goods, condiments and in toiletry products such as mouth washes and dental creams. It also finds a prominent place in the flavouring of baked goods, such as spiced meat, sausages, tomato pastes, various kinds of sauces, catsups, fancy vinegars, pickles, ketchups and beverages. In the perfumery industry, the oil is used for compounding certain popular perfumes notably, jasmine blends.

Various uses are attributed to different parts of the plant in indigenous system of medicine and homeopathy. Thus, an infusion of the plant is used for cephalalgia, gouty joints and as a gargle for foul breath. The juice, obtained from the leaves, gives relief in irritation of throat, earache and ringworm. Seeds are used internally in constipation and piles.

De Silva/jbg
16 Sept. 1992

Backstopping Officer's Technical Comments
based on the work of S. Jain, SI/ETH/90/802/11-02

The report is very comprehensive with a lot of detailed information in the annexes. The consultant has successfully carried out the duties as per job description in a shorter period than envisaged. He has done a study of the current status of the production of essential oils and marketing. Corrective measures to improve production have been recommended. The workshops and seminars conducted by the consultant have enriched the knowledge of the counterpart staff in all areas of the essential oils industry.

The technology to improve yields both by using correct agronomical practices and efficient processing has been transferred. The ways and means of contacting the trading houses and achieving the quality requirements for international trade have been recommended.

A detailed report for the development of the essential oils industry in Ethiopia has been submitted along with requirements for the production of aroma chemicals and the creation of a sensory evaluation laboratory. It is hoped that those recommendations will be taken up for implementation on a priority basis.

The annexes contain a lot of very valuable information for the development of the essential oil industry and marketing of quality oils and aroma chemicals. The technical assistance programme recommended by the consultant would be very useful and important to develop pilot scale processing to develop parameters for industrial production.

The consultant has done a very efficient and thorough job during his mission.