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TECHNO-ECONOMIC DEVELOPMENT OF MEDICINAL AND AROMATIC PLANTS FOR INDUSTRIAL UTILIZATION IN NIGERIA

DG/NIR/92/015/11-53, 54; 17-09

NIGERIA

Technical report: work performed and recommendations*

Prepared for the Government of Nigeria
by the United Nations Industrial Development Organization

Based on the work of Angus Hone, Marketing Consultant, Sudir Jain, Plant Product Technologist and J. O. Odama, Macro-Economist

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* This document has not been edited.

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TABLE OF CONTENTS

ABSTRACT

The mission took place between 21st April and 21st May, 1997 during which time the consultants worked with the NPD and other project counterparts in Abuja. The consultants exhaustively covered all parts of their mission as set out in the job description(Annex 1).

The consultants carried out the following functions:-

- Assessed the raw material availability and made an estimate for systematic cultivation
- Determined R&D needs for product development
- Made a cost benefit analysis of distillation/extraction.
- Made a cost benefit analysis of secondary processing/value addition.
- Determined the potential for formulation of oils/extracts into cosmetics/fragrances/medicinal plants.
- Assessed the marketability of oils/products (local, regional and International)
- Determined the feasibility of rural production and the economies of scale
- Explored the possibilities/potential for import substitution(flavours,cosmetics, fragrances, formulations)

In addition to the functions described above the following work was also done:-

- The economic background to production of Medicinal and aromatic plants and their industrial utilization was determined. The details are attached herewith as annex 8.
- The required management structure to support the demonstration cum production pilot plant was determined. The details are attached herewith as annex 9.

1. INTRODUCTION

The project intends to provide institutional facilities which will strengthen the capacity and technical capability of the National Institute for Pharmaceutical Research and Development (NIPRD), to enable it to operate multi-disciplinary research on the medicinal and essential oil containing plants which are locally available vis-a-vis isolation, identification, production and pharmacological evaluation of such products.

Given the present demand in the world markets, considerable scope exists for the establishment of cultivation of these essential oil bearing plants, particularly Lemongrass, Eucalyptus citriodora, and for the distillation of their essential oils which can be done by the farmers at the field level in small scale stills and Ginger and Chillies where the cultivation can be done by the farmers and extraction can be done in centralised units.

The Government accordingly requested the UNIDO to provide technological support by way of International and National Consultants to determine the techno-economic feasibility of such a project and hence the missions.

2. FINDINGS, OBSERVATIONS AND WORK PERFORMED

1. Assessment of Raw Material Availability and Estimate for Systematic Cultivation

As a result of observations made, changes in emphasis were required because of lack of collection of detailed data on production values, costs and prices of the seven crops. The emphasis of the consultants has therefore been concentrated on three crops whose agrotechnology details were available with them. These are the crops requiring the processing of fresh green leaves in field stills close to the growing areas i.e. Lemongrass, Citriodora and Ocimum.

Hard data on the actual systematic cultivation of these three crops with regard to leaf and oil production has not been developed along with yield and price data because there is no systematic cultivation of these crops in Nigeria.

Mitracarpus scaber: It was found that this plant was an endemic weed growing in large tracts of central Nigeria but there is almost no data on its cost of collection and transport for processing to potential production units.

Ginger and chillies : The team observed and found that both Ginger and Chillies (Capsicum frutescens which is the variety mainly grown in Nigeria) are grown and traded competitively from Nigeria to export markets in large volumes as well as being consumed locally.

It was found that no selection and breeding of high yielding variety of these two plants had been done. It was felt that this activity combined with improved post harvest handling (drying and peeling) would render the production of ginger oil, ginger oleoresin and chillies oleoresin an economically viable activity.

The Pilot plant would be able to prove the economic and financial viability of commercial production of oleoresins and essential oil from these two crops.

Aloe vera: The gel from this plant is used as a skin ointment, suntan lotion ingredient and as a health drink. The world production is dominated by massive farms in the southern United States (states such as Florida, Texas and Arizona). The processing of Aloe vera leaves and the extraction of the gel require totally different facility such as airconditioned and cooled production processing unit as compared to the other plants under consideration.

There is no systematic cultivation of Aloe vera in Nigeria and the team believed that in the absence of any detailed data sets relating to experimental cultivation, the growing and processing of Aloe vera was most unlikely to be competitive with the large US growing processing units.

The plants receiving priority analysis in this report are those where Nigeria is already a competitive producer e.g. Ginger and Chillies and those plants offering good prospects of systematic cultivation on individual or groups of farms where these can be processed through field stills e.g. Ocimum, Lemongrass and Citriodora.

The lack of analysis of Mitracarpus scaber and Aloe vera has been caused by a complete absence of data in the case of Mitracarpus scaber and the belief that contribution and processing of Aloe vera is not likely to be competitive in comparison with major US users.

- It was found that raw material for processing in commercial quantities was available only in the case of Ginger and to some extent Chillies. Both are grown as food crops in Nigeria and dry Ginger is a regular item of export.

- It was found that Eucalyptus citriodora trees were being grown in substantial numbers for the purposes of generating firewood and wooden poles. As and when the trees are cut down, the leaves become available as a by product. It was found that the quantity of leaves available was inadequate for undertaking commercial production of Citriodora oil since the total area under Citriodora trees was only 96 hectares.

- It was found that Lemongrass was not being cultivated as a crop anywhere. It was planted by many people around their homes as a garden plant. It was found that not enough leaves could be gathered to do distillation on a commercial scale. It was also found that the NIPRD has a one hectare trial plantation of Lemongrass.

- As regards Ocimum grattissimum, it was found that no plantation existed and only a few plants were growing on the NIPRD farm.

- It was found that Aloe vera was also not planted anywhere. A few plants were found to be available in the NIPRD nursery.

- It was found that Mitracarpus scaber grows wild in the country every where and sufficient material could be harvested for commercial use. No attempt had been made to cultivate the crop.

2. Determination of R & D Needs for Product Development

It was found that in the case of the seven plants with which the project was concerned, no concentrated R&D efforts had been made to date. It was also found that project counterpart staff were not oriented in the areas of cultivation, distillation and utilisation of aromatic plants and had not received any agrotechnology and chemical technology inputs for undertaking any R&D work. It was determined that proper cultivation, distillation and utilization of aromatic plants would not be possible without organised R&D work. It was also determined that the following R&D work was required to be undertaken to meet the project objectives.

- Establishment of standard agrotechnolgy practices.
- Standardisation of distillation and extraction processes.
- Investigation and standardisation of secondary processing/ value addition technologies by way of production of isolates and derivatives from locally produced essential oils.
- Establishment of a Fragrance and Flavour blending laboratory and training of personnel to operate

the same.

- Establishment of a fully equipped Quality control laboratory to assess the quality of essential oils being produced and thus determine their marketability. (It was found that though the NIPRD has a gas-liquid chromatograph, the same was not functional).
- Establishment of an applications laboratory to formulate cosmetics, toiletries, soaps, detergents and aerosols.

As a means of providing the first technological input to achieve the aforementioned R&D targets, the following work was done by the Plant Products Technologist:

- Detailed Agrotechnolgoy notes in respect of the following were provided(See Annex 2) :-

  Lemongrass — Eucalyptus citriodora
  Ocimum grattissimum — Ginger
  Chillies.

- A sketch of a typical field still to distill essential oils was provided (Annex 3) along with the correct procedure for operating the same.

- The correct method of Fractional Distillations was provided and explained to enable NIPRD to fractionate essential oils(Annex 4).

- Process details in respect of isolates and derivatives that can be prepared from Lemongrass and Citriodora oils were provided to enable the NIPRD to undertake development work to standardise the products and engage in secondary processing of essential oils to add value to basic materials.

  In addition a typical synthesis of Flavour chemicals was provided to initiate work on the development of Flavours(Annex 5).

- To enable the NIPRD to establish the nucleus of a Fragrance and Flavour laboratory, formulae of fragrances and flavours were provided which demonstrated the following:-

  Use of locally produced essential oils as such in fragrances.
  Use of fractions of locally produced essential oils in fragrances.
  Use of isolates and derivatives of locally produced essential oils in fragrances.

In addition formulae of flavours were also provided to teach the basics of flavours blending to NIPRD staff(Annex 6).

In addition 3 Seminar-cum-workshops were held to introduce the NIPRD staff to the workings ofthe essential oils and Fragrance and Flavours Industry.

3. Determinations of Cost-Benefit Analysis of Distillation/ Extraction

It was found that essential oils such as those of Lemongrass, Eucalyptus citriodora and Ocimum grattissimum which are produced from green herbage must be distilled fresh in the same area in which they are harvested. It was found that this can be achieved by using field stills which can be operated by a farmer or groups of farmers. A cost benefit analysis has been done taking a hypothetical unit as a model since none actually exist on the ground:

Cost in US DOLLARS **US $1 = N85 IN MAY 1997**

Fixed Assets

Field Still	10,000
Shed	500
Water tank	500
Cost of land	-
Cost of well	500
Total	$11,500

Depreciation @ 20%	$2,300
Interest @ 25%	$2,875
Consumables	
Fuel (firewood)	$1,000
Running costs	
Labour	$1,000
Transportation	$ 500
Packing material	
GI Drums/PP barrels	$ 200
Total	$7,875

Benefits in US Dollars

The benefit is calculated by deducting the total estimated expenses from the total revenue expected per annum per oil as under :-

Item	Yield per Ha	Price/Kg	Revenue from 10 ha
Lemongrass oil	100 kg	$12.00	$12,000
Citriodora oil	200 kg	$04.50	$ 9,000
Ocimum oil	60 kg	$18.00	$10,800

Therefore the profit from the cultivation and distillation of each oil is as under:-

Lemongrass oil	US $4125
Citriodora oil	US $1125
Ocimum oil	US $2925

Note:
The still is assumed to work for 200 days in a year, take a charge of 200 kg of green herbage and be of design such that it has no parts which require regular maintenance. It has been estimated that one field unit will be able to service 10 hectares on the basis of taking 2 charges per day.

It has thus been determined that Lemongrass is a profitable crop to plant provided the element of land and labour is provided by the farmer and his family.

It has further been determined that because of the low price of Citriodora oil, it is not feasible to plant it as the main leaf crop. Instead it should be planted as a tree crop on or along the borders of the main fields or on land which is otherwise unusable due to topography or other agro-technological reasons.

It was determined in the case of Ocimum that inspite of the theoretical feasibility, the practical aspects relating to cultivation and quality of oil have to be standardised before any proper analysis can be done.

Ginger and chillies are required to be processed for Ginger oil, Ginger oleoresin and Chillies oleoresin in a centrally located plant similar to the pilot plant installed in the project premises.

Ginger

Yield of green Rhizomes per hectare:	10,000kg
Yield of dry ginger per hectare:	2,000kg
Yield of Ginger oil @ 2%:	40kg
Yield of Ginger oleoresin @ 6.5%:	130kg

The yield of green rhizomes has been estimated on the conservative side and the yields of oil and oleoresin have been estimated on average basis as obtained elsewhere in the main growing countries.

Value Realised Per Hectare of Ginger Cultivation

Price of Ginger oil per kg:	US $ 30
Therefore value realised:	US $1200
Price of Ginger oleoresin:	US $ 18
Therefore value realised:	US $2340
Therefore total value realised :	US $3540

Value Realised Per 100 Hectares of Ginger Cultivation: US $354,000

Cost in US DOLLARS

Fixed Assets

Extraction plant	$200,000.00
Land and building	$ 10,000.00
Water Tank	$ 500.00
Cost of Water source	$ 500.00
Total	$211,000.00

Depreciation @ 10%:	$21,100.00
Interest @ 25%:	$52,750.00
Consumables	
Fuel (Diesel type)	$ 6,000.00
Raw material	
Dry Ginger(200,000 kg) @ US $0.60 per kg.	$120,000.00
Solvent	$ 15,000.00

Running Costs	
Labour	$ 5,000.00
Transportation	$ 5,000.00
Packing Materials	$ 10,000.00
Total	$ 234,850.00

We can therefore say that the profit to be earned from an extraction plant able to service 100 hectares of Ginger plantations would be $119,150.00 from which post production expenses like inland haulage and sea/air freight would further have to be deducted.

It is therefore well established that a Ginger oil/Ginger oleoresin production plant would be profitable provided the capacity and yields assumed are achieved. The capacity and yields are being assumed on the basis of standard data because no work has actually been done with Nigerian material and as such hard local data is not available.

CHILLIES

Yield of fresh fruits per hectare: 15000 kg
Yield of dry chillies per hectare: 1500 kg
Yield of chillies oleoresin @ 10%: 150 kg

The yield of fresh fruits has been estimated on the conservative side and the yields of oleoresin have been estimated on average basis as obtained elsewhere in the main growing countries.

Value Realised Per Hectare of Chillies Cultivation

Price of Chillies oleoresin per kg: US $ 30
Therefore value realised: US $ 4,500

Value Realised per 100 Hectares of Chillies Cultivation: US $450,000

Cost in US DOLLARS

Fixed Assets

Extraction plant	$200,000
Land and building	$ 10,000
Water Tank	$ 500
Cost of Water source	$ 500
Total	$211,000

Depreciation @ 10%:	$21,100
Interest @ 25%:	$52,750
Consumables	
Fuel (Diesel type)	$ 6,000
Raw material	
Dry chillies(150,000 kg) @ US $1.60 pkg	$240,000
Solvent	$ 15,000
Running Costs	
Labour	$ 5,000

Transportation	$ 5,000
Packing Materials	$ 10,000
Total	$354,850

We can therefore say that the profit to be earned from an extraction plant able to service 100 hectares of Chillies plantations would be $95,150.00 from which post production expenses like inland haulage and sea/air freight would further have to be deducted.

It is therefore well established that a Chillies oleoresin production plant would be profitable provided the capacity and yields assumed are achieved. The capacity and yields are being assumed on the basis of standard data because no work has actually been done with Nigerian material and as such hard local data is not available.

4. Cost Benefit Analysis of Secondary Processing/Value Addition

Out of the five plant species targeted in the project, two are capable of being processed for secondary processing.

It was determined that these were:

- Lemongrass oil
- Eucalyptus citriodora oil

The products which are obtained from these are:

Lemongrass oil

Citral
Citronellol
Nerol
Citronellyl Acetate
Citronellyl Butyrate
Neryl Acetate
Ionone alpha Beta or 100%
Methyl Ionone
Alpha Ionone

Eucalyptus citriodora oil

Citronellol
Citronellyl Formate
Citronellyl Acetate
Citronellyl Butyrate
Hydroxycitronellal

A comparative analysis of the yields and prices obtained further products gives a clear picture of the benefits derivable from secondary processing:-

Starting material	Cost	Derivative	Yield	World Market Price
Lemon grass oil	$12	Citral	70%	$9.00
		Citronellol	65%	$10.50
		Nerol	65%	$11.00
		Citronellyl Acetate	60%	$12.00
		Citronellyl Formate	60%	$12.00
		Citronellyl Butyrate	60%	$12.50
		Ionone 100%	50%	$16.00
		Methyl Ionone	50%	$18.00
		Alpha Ionone	50%	$25.00

Starting Material	Cost	Derivative	Yield	World Market Price
Citriodora oil	$4.50	Citronellol	65%	$10.50
		Citronellyl Acetate	60%	$12.00
		Citronellyl Formate	60%	$12.00
		Citronellyl Butyrate	60%	$12.50
		Hydroxy citronellal	60%	$24.00

It is thus evident that Lemongrass oil cannot be profitably processed to make secondary derivatives because of the high cost of Lemongrass oil as compared to the low cost of the same derivatives obtained from turpentine oil. The oil itself is a highly marketable commodity and has a large world market amounting to 250-300 tonnes per annum.

Eucalyptus citriodora because of its low price is suitable for secondary processing, provided it can be produced in sufficiently large quantities. However the low prices of citriodora renders it unprofitable for cultivation as the main crop and hence it must be cultivated as a secondary crop in sufficiently large quantities to generate enough oil to make the secondary derivatives.

An estimate of cost of equipment and processing costs is not being made because of uncertainty regarding the availability of these oils and lack of any R&D work done in this area to establish the processes on which the cost of equipment and processing costs are dependent.

5. Determination of Potential for Formulation of oils/extracts into cosmetics/fragrances/medicinal products

It was determined that the following consumer goods industries exist in Nigeria:-

- Toilet Soaps and washing soaps.
- Detergents and washing powders
- Shampoos
- Creams
- Tooth pastes
- Bakery
- Fruit Processing

Since all these industries are consumers of fragrances and flavours, a market exists for these products which is today being catered to by products imported from international companies.

In order to exploit this market potential the technology for formulation of flavours and fragrances has to be inducted into the country which is at the moment non-existent.

It was determined that the NIPRD had received no input in this area under the aegis of the Project and as such to remedy this situation, some formulations of flavours and fragrances were provided to counterpart staff and 3 seminar cum workshops were held to introduce the counterpart staff to the working of this industry.

It was found that there was need to do the following if any further progress was to be made in this area:-

- establish a Flavours and Fragrances Blending Laboratory
- Equip the laboratory with a sufficient variety of raw materials
- Determine the prices and sources of raw materials.
- Train personnel to use the raw materials
- Train personnel to learn blending techniques and formulations.
- Establish an applications laboratory to test the blends and formulations.
- Establish an interface with the industry to transfer the know how to entrepreneurs.

It was determined that given these inputs it was possible to establish a viable domestic industry to meet the needs of Nigerian consumers.

It was also determined that if such an industry was to be established , the secondary processing of essential oils produced in Nigeria would also become a much more viable proposition leading to :-

- Consumption of derivatives even at a price higher than the international price because easy domestic availability would offset the differential.
- Support to Nigerian farmers undertaking the cultivation of aromatic plants and distillation of essential oils
- Viability of small scale production thus obviating the need to initially enter the international market where large quantities are required for trading
- Standardisation of procedures and techniques leading to large scale manufacture in due course.

6. Assessment of Marketability of oils/products (local, regional, international)

It was determined that the following requirements had to be fulfilled before marketing of essential oils could be done:-

Local

- A domestic Fragrances and Flavours industry had to be established to consume the locally produced essential oils. There exists no market as such for essential oils in Nigeria.
- A domestic secondary processing industry producing Aroma chemicals - both isolates and derivatives had to be established to supplement the Fragrances and Flavours industry.

Regional

Within the region the same situation prevails that there is no fragrance and flavour industry to consume essential oils. Citrus oils are produced in West African countries such as Ivory Coast but they are all destined for export to European markets because of tie-ups with international companies and large volumes produced.

International

Essential oils can be traded in the international markets only if large volumes are available on a regular basis and since the essential oils industry is in its infancy in Nigeria, the following has to be achieved if marketing at an international level is to be done:-

- Establishment of cultivation of aromatic plants on a large scale on the basis of correct agrotechnology adapted to Nigerian conditions.
- Establishment of field stills spread throughout the growing regions.
- Establishment of a collection and payment system for oils produced in the field.
- Establishment of bulking, grading and quality control of the oil produced either at the public or private sector level.
- Establishment of contacts with the international community of brokers, dealers and consumers.

It was found that these facilities did not exist on the ground at present and as such it was determined that under the existing conditions no trading at the international level was possible. However since the oils being considered are traded in the International market, the fundamental potential exists.

7. Determination of Feasibility of Rural Production and Economies of scale

It was found that practically the entire agriculture in Nigeria was being carried out under subsistence conditions. It was found that the use of mechanical implements such as tractors, fertilizers, herbicides, pesticides and irrigation were almost negligible.

It was determined that most farmers followed a mixed crop pattern in which various crops required were planted according to the season under subsistence conditions and grew within the limits placed by lack of standard agrotechnology practices. It was determined that only a small portion of the total national agricultural production entered the market system thus leading to limited monetisation of the farmers labour and produce and perpetuation of subsistence agriculture.

It was determined that for rural production of essential oil bearing aromatic plants to become feasible, the following would have to be achieved:-

- Agrotechnology practices based on intensive agriculture would have to be introduced.
- Within conjugate areas, wherever possible intercropping of aromatic plants would have to be introduced to provide sufficient material for distillation to support the field stills.
- Demonstration farms would be required to be created to show the farmers the results achievable from aromatic plants.
- A marketing infrastructure would have to be created to ensure that the oils produced in the field are sold so as to encourage the farmers to continue.
- Nurseries to preserve, select and multiply planting material would have to established.

It was determined that under these conditions rural production of aromatic plants would be feasible, with the proviso that unless and until new areas are opened up for large scale cultivation, the pressure of food corps and their instant marketability would deter farmers in engaging in monocropping of aromatic plants. It was determined based on their observations that proper intercropping in conjugate areas and farms would provide the most suitable method for cultivation of aromatic plants.

8. Exploration of the Possibilities/Potential for Import Substitution (flavours, cosmetics, fragrances, formulations)

As already detailed under serial no. 5, the findings and observations lead to the conclusion that import substitution would only be possible if there was a domestic industry producing Fragrances, Flavours and Aroma chemicals and as such it is reiterated here that the establishment of such industries is necessary if any degree of import substitution is to be introduced.

9. Determination of Management Structure for Pilot Plant

It was determined after examining the working of the Pilot Plant that a very efficient and comprehensive system of management would have to be put in place to manage the Pilot Plant and not only use it as a demonstration and process development unit but also to use it as a revenue generating profit centre. The details are attached herewith as Annex 9.

10. Raw Material Requirement By Sector

It was determined that there was a substantial requirement for various raw materials such as Essential oils, Fragrances, Flavours, Oleoresins and Aromatic chemicals for the domestic Nigerian Industries. The details have been taken from work done by Dr. O. A. Aribisala. The details are attached herewith as Annex 10.

3. CONCLUSIONS

1. It was concluded that except for Ginger and to some extent chillies, no other aromatic plants crop was growing in sufficient acreage to support a commercial industry. It was also concluded that except for Ginger and chillies there was no systematic cultivation of aromatic crops.

2. It was concluded that extensive R&D work was required to be undertaken in the following areas along with training of personnel:-

-Agrotechnology
-Distillation and Extraction Process Technology

-Isolates and Derivatives Production Process Technology (Secondary Processing).
-Fragrance and Flavour Blending Technology
-Quality Control techniques
-Applications Technology

3. It was concluded that the cost-Benefit analysis was favourable in the cases of :-

-Lemon grass
-Ocimum
-Ginger
-Chillies

and as indicated their cultivation, distillation and extraction should be taken up on a large scale.

In the case of E. citriodora, it was concluded that it is more suited for intercropping because the cost-benefit analysis suffered from the low price obtainable for this oil in the world market.

4. It was concluded that secondary processing of Lemon grass oil was not feasible due to its high cost in the world market. It was further concluded that E. citriodora oil with its low price was suitable for secondary processing from the point of view of value addition, provided suitable methods could be evolved for its cultivation which is unattractive due to its low price.

5. It was concluded that potential existed for the establishment of a Flavours and Fragrances Blending industry to meet the demands of Nigerian Industry in the following sectors:-

- Soaps
- Detergents
- Cosmetics
- Toiletries
- Perfumes
- Bakery
- Confectionery
- Soft Drinks
- Processed foods
- Jams, Pickles and chutneys

provided the following facilities were created:-

- Fragrance and Flavour Blending Laboratory equipped with the full variety of raw materials whose sources and prices have been determined and personnel trained.
- Applications Laboratory to test the flavour and fragrance blends created by the fragrance and flavour laboratory.

It was further concluded that such an industry if created would provide impetus to the essential oils industry as well and help to consume the essential oils, isolates and derivatives produced locally while at the same time providing a ready market for the produce of the farmers engaged in the essential oils trade which in turn would help in standardising agro- technological practices for large scale production.

6. It was concluded that the marketability of essential oils produced in Nigeria would be enhanced by the establishment of a domestic fragrances and flavours and secondary processing industry in the first phase to be followed by large volume production based on the following principles:-

- Use of correct Agrotechnology
- Establishment of field stills
- Establishment of collection and payment system for oil
- Establishment of Quality Control facilities accessible to growers and traders.
- Establishment of commercial contacts with the international fragrances and flavours trade.

7. It was concluded that the feasibility of Rural Production of Aromatic Plants could be established provided the following steps were taken:-

- Introduction of correct Agrotechnology and Intensive Agriculture
- Introduction of inter-cropping of aromatic plants with usual crops wherever possible.
- Establishment of Demonstration farms
- Establishment of marketing infrastructure
- Establishment of Nurseries to preserve, select and multiply planting material.
- Opening up of new areas for cultivation of aromatic plants to isolate them from the pressure of food crops.

8. It was concluded that import substitution in the areas of fragrance, flavour and cosmetics could be undertaken with the creation of a domestic fragrance and flavours and Aromatic chemical Industry backed by proper R&D facilities and trained personnel.

9. It was concluded that the management of the Pilot Plant was required to be carried out by a dedicated team of professionals who would be specialists in the areas of production, maintenance, fabrication, cultivation, distillation, quality control, and cost accounting. It was also concluded that sufficient scope existed for using the Pilot Plant as a Process Development cum Demonstration cum Production Unit.

4. RECOMMENDATIONS

1. It is recommended that:-

- Ginger :Selection of higher yielding varieties with better aroma and oil content and their multiplication and release to farmers should be undertaken
- Chillies: Selection of higher yielding varieties with their classification on the basis of colour and pungency content should be done and the desirable varieties should be made available to the farmers
- Lemon grass: large scale and systematic cultivation should be encouraged.
- E. citriodora: Extensive inter-cropping with the usual food crops should be encouraged in conjugate areas.
- Ocimum: further investigation of cultivation and oil quality should be carried out.

2. It is recommended that extensive R&D work should be undertaken in the following areas along with training of personnel:-

- Agrotechnology
- Distillation and Extraction Process Technology
- Isolates and Derivatives Production Process Technology
- Fragrance and Flavour Blending Technology
- Quality control Techniques
- Applications Technology.

3. It is recommended that the cultivation, distillation and extraction of Lemon grass, Ginger and Chillies should be undertaken on a large scale and they should be propagated extensively. It is

also recommended that Eucalyptus citriodora should be propagated as a coppiced tree intercropped with the usual food crops and yielding leaves as the main produce.

4. It is recommended that efforts in the area of secondary processing should be concentrated on E. citriodora oil because of its current economic price in the world market.

5. It is recommended that the following facilities be created to move towards the goal of having a domestic fragrance and flavours industry:

- Fully equipped Fragrance and Flavours Blending Laboratory manned by trained personnel.
- Fully equipped Applications Laboratory manned by trained personnel.

So as to be able to service industries such as soaps, Detergents, Cosmetics, Toiletries, Perfumes, Bakery, Confectionery, Soft Drinks, Processed Foods, Jams, Pickles and Chutneys.

6. It is recommended that the marketability of essential oils produced in Nigeria should be enhanced by the establishment of a domestic fragrance, flavours and aroma chemicals industry leading to the consolidation of the essential oils industry and eventual large scale production, based on the following principles:-

- Agrotechnology
- Network of field stills
- Systematic collection and payment for oil
- Easily accessible quality control facilities
- Commercial interaction with the international trade and industry.

7. It is recommended that the feasibility of rural cultivation of aromatic plants should be established on the basis of :-

- Agrotechnolgy and intensive cultivation
- Systematic inter-cropping
- Demonstration farms
- Marketing infrastructure
- Nurseries to preserve, select and multiply planting material
- Opening up of new areas for cultivation.

8. It is recommended that the Pilot Plant Project Management Team should be selected and put in place at the earliest to ensure optimum utilisation of the Pilot plant facilities.

Annexure 1

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION AND POST TITLES

1. Consultant in Marketing
   (Ref. DG/NIR/92/015/11-53/0730A0)
   Duration 1.2 MM Month (1M/M in the Field) One Week home-based)

2. Plant Product Technologist
   (Ref DG/NIR/92/015/11-54/0730A0)
   Duration 1 Man month

3. National Expert (Macro Economist)
   (Ref DG/NIR/92/015/17-09)
   Duration 2 MM Month

Duty Station Abuja, Nigeria.

Purpose of Project: The Project intends to provide institutional facilities which will strengthen the capacity and technical capability of the National Institute for Pharmaceutical Research and Development (NIPRD), to enable it operate multi-disciplinary research on the medicinal and essential oil containing plants which are locally available vis-a-vis isolation, identification, production and pharmacological evaluation of such products.

Duties: The consultant together with the marketing consultant (team leader) and the national expert (macro-economist) and in cooperation with the NPD and counterpart staff should collect, determine, evaluate and analyze required data with respect to the following aspects and prepare a report on the techno-economic feasibility of the industrial utilization of the seven plants (Ocimum gratissimum, capsicum annum, Zingiber officinale, Cymbopogon citratus, Mitracarpus scaber, Aloe vera, Eucalyptus citriodora).

- Raw material availability and estimates for systematic cultivation
- R & D needs for product development
- Feasibility of rural production and economy of scale

- Possibilities/potential for import substitution (flavours, cosmetic fragrance, formulations)

- Cost benefit analysis of distillation/ extraction

- Cost benefit analysis of secondary processing/value addition

- Potential for formulation of oils/exatracts into cosmetics /fragrances/medicinal products.

- Marketability of oils/products (local, regional, international)

The consultants should prepare a comprehensive joint report (on Word Perfect 5.2 to submit to UNIDO on a diskette and a hard copy) incorporating the findings, analysis and recommendations including the techno-economic feasibility of undertaking industrial utilization of the above seven plants.

Qualifications — An economist/marketing analyst with over 10 years of experience in the marketing of plant based products. Knowledge of markets for medicinal and aromatic plant products would be an advantage.

Language — English

Annexure 2

AGROTECHNOLOGY

1. Lemon grass oil; Cymbopogon citratus

Cultivation:

A warm and humid climate with plenty of sunshine and rainfall ranging from 250-300 cm, uniformly distributed over the year is ideal for the cultivation of the plant. It grows well at altitudes up to 1200 m even on poor soils along the hill slopes.

The grass grows best on well drained sandy loam soil.

The plant is propagated from rooted slips. The slips are planted at a distance of 45-60 cm in rows 60-70 cm apart. In areas receiving high rainfall, planting on ridges is recommended.

In areas receiving well distributed rainfall no irrigation is required. However frequent irrigation is necessary for optimum yield in those areas where rainfall is irrestricted to the rainy season only and borehole and pump may be required.

Generally 2-3 weedings are necessary during the year.

Lemon grass is a soil exhausting crop. Sufficient amount of nitrogen and potash are required as growth factors. 30 kg of DAP and 30 mg of potash per hectare are recommended as basal dose at the time of planting. 60 kg of urea can be applied as top dressing in 3-4 split doses during the growing season.

The first harvest of grass is obtained three months after planting. Subsequent harvests take place at intervals of 50-55 days. Generally three harvests are possible during the first year and four in subsequent years. Harvesting is done with the help of sickles, the plants being cut close to their base about 10 cm above ground level. The plantation once established is good for 4-5 years.

DISTILLATION.

The grass is distilled fresh. It should not be allowed to wilt for more than 24 hours. Both hydro distillation and steam distillation methods may be used. On an average one hectare produces 75-100 kilos of oil annually. The percentage of oil yield based on fresh leaf weight varies between 0.2 to 0.4.

The spent grass may be used as fuel for subsequent distillations. It may also be composted to give good manure or used for mulching.

SPECIFICATIONS

Appearance: Pale yellow to brownish liquid with a pronounced sharp, pungent lemon like odour.
specific gravity : 0.872-0.900 at 20°c
Refractive index: 1.4830 - 1.4890 at 20°c.
Optical Rotation: - 30 to + 1° at 20°c.
Aldehyde content as citral: 75-76%
Its main constituents include isovaleric aldehyde, furfural, myrcene, dipentene, methyl heptenone, aldehyde c-10, citronellal, linalol, geraneol, nerol and terpenes.

2. Eucalyptus citriodora

CULTIVATION

Tropical and sub-tropical climates are preferred for cultivation. It grows satisfactorily in temperate climates also where however it is frost sensitive in the early stages. It can be grown in any type of soil up to an altitude of 600 m, in rainfed areas.
Plants are raised through seeds only. Seedlings are raised first in nursery directly in polythene bags filled with an equiproportional mixture of garden soil, compost and sand or sandy loamy soil. Seeds germinate in 4-14 days depending upon atmospheric humidity and temperatise. Seedlings should be grown in nursery for 10 weeks and should be transplanted in the field after attaining a height of 20-30 cm.

Plantation should be done with a spacing of 90x75 cm.
120 kg urea per hectare applied through soil produces the best results by increasing the herbage yield.

Harvesting should be done twice in a year, once before the onsets of the rainy season and second after the completion of the rainy season.

The pronounced shoot potentiality of E. citriodora is a very advantageous character for regular supply of leaves. Plants are pruned to promote a vigourous sprouting of side branches. Fresh Shoots sprout in 4 weeks after pruning which are ready for cutting in 4-5 months. The process results in regular increase in yield of leaves which is stabilised when the plants are 3 years old. The first pruning is done at about 30-45 cm above the ground and the subsequent prunings are done at 75-90 cm above the ground. Usually three harvests are possible in a year if sufficient water is available.

DISTILLATION

The leaves are steam or hydro distilled for oil. The herb is distilled soon after harvesting to avoid loss of oil through evaporation as well as its deterioration during shortage.

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. The oil yield varies from 0.5 to 2%.

Specification:

Specific Gravity: 0.8640 - 0.8770 at 20 c
Optical Rotation: + 3o - 3o at 20 c
Refractive index: 1.4511 - 1.4570 at 20 c
Citronellal: 65-85% content

3. **OCIMUM GRATISSIMUM**

CULTIVATION

Moderately fertile well drained loamy or sandy loam soils are considered ideal for its cultivation.

The crop is raised through seeds. Seedlings are first raised in the nursery and then transplanted in the field. About 125 gm seeds provide sufficient seedlings for planting one hectare. Seeds start germinating 3-5 days after sowing and germination is over in about 10 days. The seedlings when 6-10 cm tall are transplanted in the field 40 cm apart in rows 60 cm apart.

A basal fertilizer application of 40kg DAP and 40kg potash per hectare before planting gives a good crop. 40kg of Urea per hectare may be applied as top dressing, split into two equal doses.

The crop is harvested when the plant is in full bloom. The crop usually comes to full bloom 8-12 weeks after planting. Corresponding to the part harvested, two grades of oil are obtained, i.e. flower and herb oil. The flower oil has a superior odour. While harvesting the whole herb, care should be taken that the plant is cut not less than 15cm from the ground, otherwise the plant will not regenerate.

DISTILLATION

The flowers and/or the whole herb is distilled by hydro or steam distillation. An average yield of 0.1 to 0.3% oil achieved.

4. **CAPSICUM ANNUM**

CULTIVATION

Chili is a warm weather crop and is generally suitable for cultivation in areas with 60 to 150cm of annual rainfall. Very heavy rainfall during crop growth is harmful. The chili plant can withstand fairly high temperatures but its fruit setting is hindered by high temperatures. The ideal temperature for growth

and fruiting ranges from 21° to 27°C. Dry winds during flowering and fruiting cause flower plus fruit drop.

The crop can be grown almost from sea level to an attitude of 1500m in tropical and subtropical areas.

Well drained sandy loamy soils with good fertility and moderate pH give good results. The field should be ploughed 4-5 times followed by 4-5 plantings in order to prepare the field.

The nursery is raised on a high well raised bed as stratgnation of water is not good for the crop. 1.5 to 2.0kg of seeds are sufficient to produce plants for one hectare.

Before sowing seeds should be soaked in water. They should be thoroughly rubbed with hand while soaking in water. This practice greatly improves germination. The seeds are sowed with a spacing of 5x5cm. After sowing water should be sprinkled morning and evening till the seedlings emerge. Overflooding should be avoided. The plants are ready for transplantation in 4-6 weeks. Transplanting can be done on ridges and a light watering should be given thereafter. The following planting distances are recommended;-
Between ridges: 45-60cm
Between plants: 45cm
200 to 300kg DAP should be applied per hectare to the soil before transplanting. 200kg of Urea per hectare should be applied after transplanting split into 3 equal doses.
Ideally farmyard manure, if available, at the rate of 250kg per hectare should be applied prior to transplanting.
Moisture stress should be avoided. The earth should be turned up twice and the land should be kept free from weeds. At least 2 weedings are required.

The crop is ready for harvesting ripe fruits in about three and a half months. Prior to this, the market permitting, if one or two pickings of green fruit are taken, then the growth of the plant is enhanced and induces them to produce more flowers and fruits. Picking continues for 2 months and up to 6 pickings can be taken during the crop.

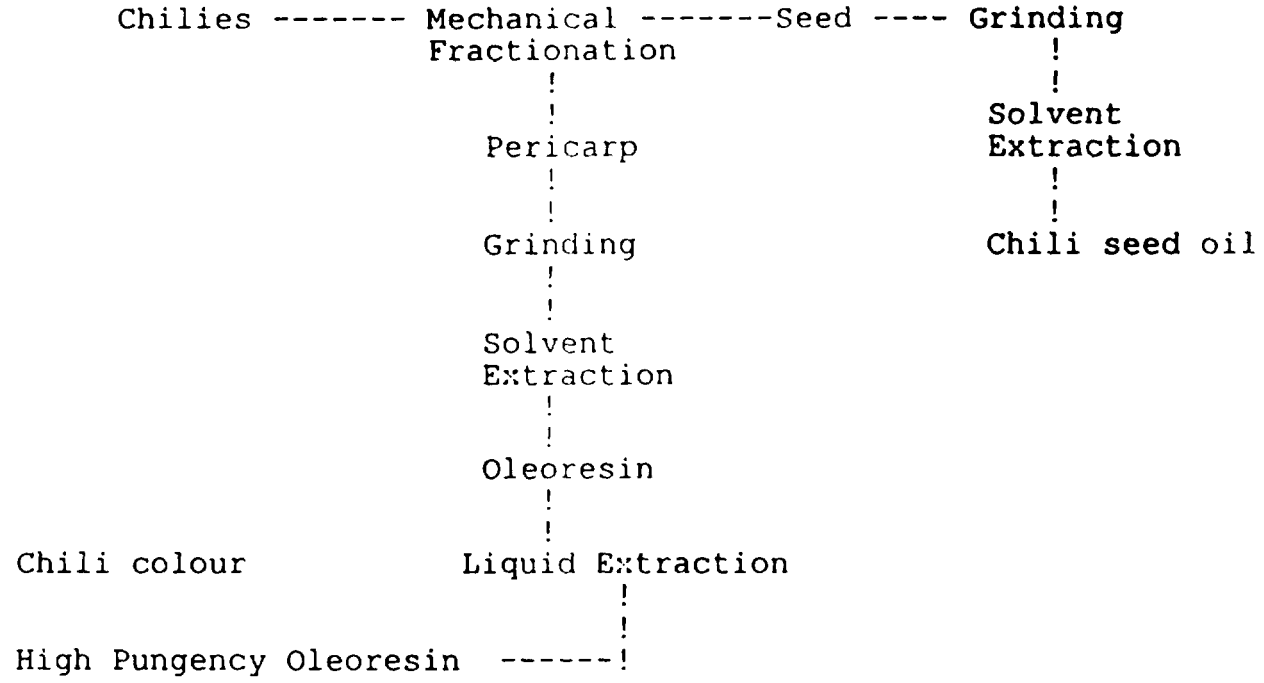
A good crop of chili in rainfed areas produces 500-1500 kilo of dry fruits.

POST HARVEST TECHNOLOGY

Upon harvesting, chilies have a moisture content of 65-80%. This is reduced to 10% to prepare the dried spice. Fresh fruits should be heaped in doors for 2-3 days, so that partially ripe fruits if any, ripen fully and the whole collection develops a uniform red colour. The best temperature for ripening is 22°-25°C and direct sunlight should be avoided. The fruits are then spread out in the

sun on hard dry ground. The fruits are turned over several times during the day so that drying is uniform and there is no discoloration or mould growth. The drying fruits are heaped at night and covered by tarpaulins or gunny bags. Drying by this process takes 5-15 days and produces 25 to 35kg dried spice from 100kg fruits.

FLOW CHART OF OLEORESIN PRODUCTION



5. GINGER

CULTIVATION

Ginger requires a warm and humid climate. The plant thrives well from sea level to an altitude of 1500m. Well distributed rainfall (150-300cm) during growing season and dry spells during land preparation as well as before harvesting are required. It can be grown in a wide range of well drained soils, of at least 30cm depth. The crop prefers light shade for good growth. It is grown mainly as a rainy season crop.

The land is ploughed 5-6 times and then planted till the soil has become smooth and free from lumps. Thereafter raised beds of size 3m x 1m are laid out at a distance of 30-45cm from each other. Small shallow pits for planting are then made on the beds at a spacing of 20cm x25cm. A handful of cattle manure is applied to each bed.

Around 900-1400 kilos of seed-rhizome is required per hectare. To select the seed rhizomes, mark healthy and disease free plants in the field when the crop is 6-8 months old and still green. Select rhizomes free from pest and disease from the marked plants. Store selected rhizomes in pits dug in shade, the floor of which is lined with sand or sawdust. Examine stored rhizomes at monthly intervals and remove rhizomes which show signs of rotting.

The optimum spacing for planting ginger is 25cm between rows and 20cm between plants. The seed rhizome should be 20-30gms in weight with at least two sprouted eyebuds. It is placed 3.5 - 5.0cm deep in the pit and soil is pressed over it, followed by light irrigation. Beds are mulched twice with green manure. Mulching prevents soil erosion, conserves moisture and is a source of organic manure. Each centre of production tends to produce a distinct type, due to differences in soil, climate and methods of cultivation,

Ginger is a soil exhausting crop and requires heavy manuring. Well rotted cattle dung or compost at the rate of 25-30 quintals per hectare is applied at the time of planting. Two mulching are given, one immediately after planting and the second about 45 days after planting. The first mulch conserves water and helps in germination. Quick rotting green leaves are used at the rate of 25 tonnes per hectare in each mulching. Cattle manure and green mulch eliminate the need for chemical fertilizers. If necessary, however, fertilizer mixture containing NPK in the ratio of 8:8:16 is applied at the rate of 750kg per hectare, one half as a basal dressing and the other half 2 months are planting.

The seed rhizomes sprout 15-20 days after planting. The beds are kept moist till the onset of rains.
Weeding is done at least three times, the first after 30 days and the 2nd and 3rd 45-60 days after the preceeding one.

Shrivelling, yellowing and withering of leaves accompanied by drying of aerial stems indicate maturity. The crop is harvested in about 7 months after planting. The rhizomes for seed are allowed to remain in the earth and are taken out 60 days later.

The average yield of green rhizomes varies from 7000 - 10,000kg per hectare with the recovery of dry ginger being 20-23%. When harvesting rhizomes, care should be taken to avoid injuring them as it reduces their market value. The adhering soil must be washed off immediately to get a pale coloured dry product. The rhizomes should not be allowed to lie in heaps for a long period as they are liable to ferment.

Ginger is marketed in both peeled and unpeeled forms. In peeled ginger, the epidermal layer of the fresh rhizome is scraped off with a sharpened bamboo splinter. Then rhizomes are washed in water and sun dried for 7-10 days. The ginger is uniformly turned

during drying. The removal of the cork skin reduces fibre content of the dried product but if done without due care, it can reduce volatile oil content by rupturing the essential oil cells which are near the surface.

During drying ginger rhizomes loose about 60-70% of their weight and attain a moisture level of 7-12%. Care must be taken to avoid mould growth during the drying process and it must be stored in a dry atmosphere. Traditional drying methods can result in loss of volatile oil content by up to 20% due to evaporation. Constant exposure to sun also results in the destruction of some heat sensitive pungent constituents. Therefore, where the ginger is to be used for essential oil and oleoresin production, ginger is sliced prior to drying to reduce the drying time as compared to whole rhizomes. This minimises the loss of oil and pungency.

ESSENTIAL OIL AND OLEORESIN

ESSENTIAL OIL: On steam distillation, unscraped, dried and comminuted ginger, essential oil to the extent of 1-3% is abtained. The oil tends to thicken and darken on exposure to light and air.

Specifications

Appearance: Pale yellow to yellow liquid with warm spicy and aromatic adour
Specific gravity: 0.822-0.884 at 20°c
Refractive index: 1.4870-1.4920 at 20°c
Optical rotation: 25o to - 52o at 20°c.

OLEORESIN

The residual matter remaining after the essential oil has been distilled is dried and then extracted with a suitable solvent like acetone or hexane. This contains the non-volatile pungent principle. The yield of acetone extractive varies from 3.6 to 9.5% with an average of 6.5%. It is a dark brown, viscous liquid or paste with the characteristic taste of ginger. Since market forces require standerdised quantities of volatile essential oil content, the essential oil distilled previously is added back in a calculatd quantity to get the material of required quantity. The general requirements is 18-35% volatile oil and this cannot always be obtained by extracting the whole ginger.

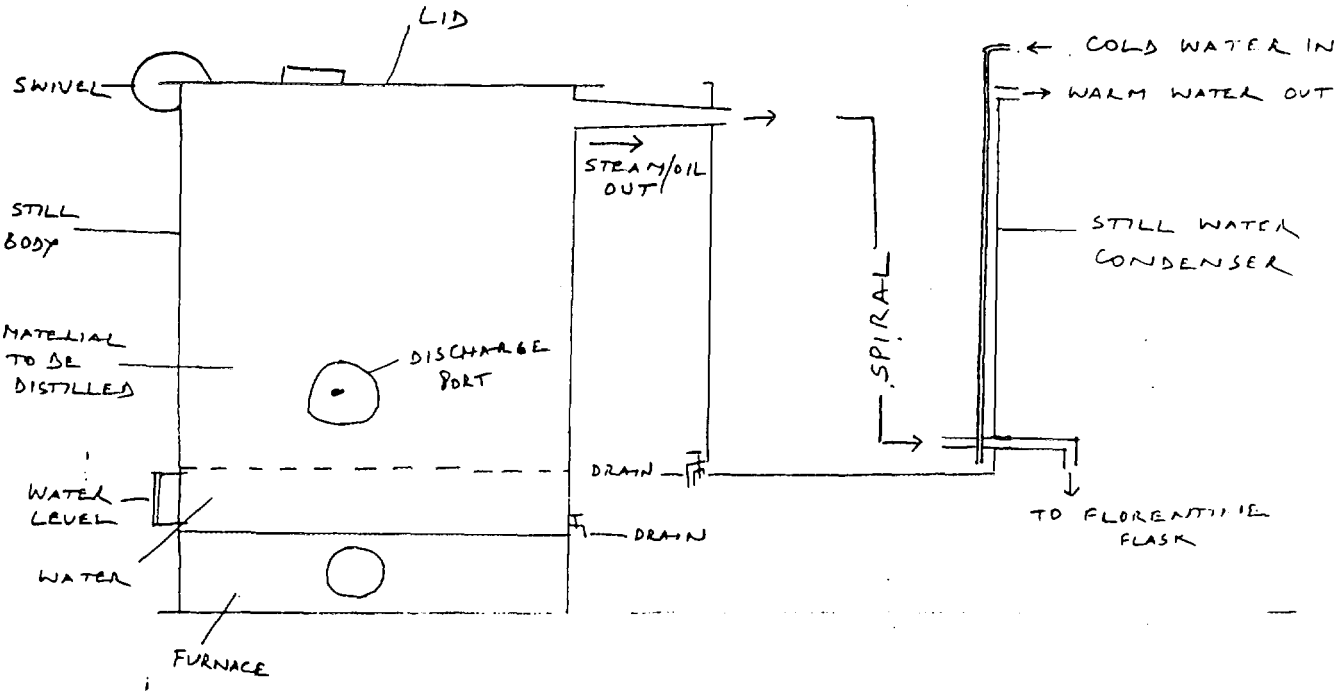
ANNEXURE 3

ESSENTIAL OIL DISTILLATION

OPERATION OF FIELD STILL:

The still is set up as illustrated in the sketch (Annexure 3). The green herbage is charged in the main body of the still along with the required quantity of water. The lid is closed. Fire is lit in the furnace, just enough to get the water boiling. The still water condenser is charged with water and the separator is put in place. The rate of fire in the furnace is adjusted so that the water boils steadily without charring the vegetable material. The steam formed gradually rises through the vegetable mass, passes into the coil, condenses and the water/oil mixture goes into the separator. The light oil rises into the neck of the separator and is drawn off from time to time. Water is drawn off from the bottom. If the essential oil has both lighter than water and heavier than water fractions, then lighter is drawn off from the top of the heavier is drawn off from the bottom and water from the middle. As the distillation progresses, the water in the still water condenser will begin to warm up. A stream of cold water is now let in and this will push one warm water at the top and keep the condenser water cold. During the distillation the water level in the still will continue to fall. If water is near finishing and oil is still coming, then the water can be topped through the water inlet. The whole still body should be insulated, say with gunny and then plastered over with clay.

After the distillation is over, the exhausted material is taken out, dried and used as fuel for the next batch, the residual water is drained and a fresh batch is charged.



Field Distillation Still(Sketch)

ANNEXURE 4

FRACTIONAL DISTILLATION UNDER VACUUM

The material to be fractionated is charged in the unit. Water is started in the condenser and the unit is opened to atmosphere. Almost all materials encountered in the Industry contain moisture. Heating of the reboiler is started gradually and the temperature is allowed to rise slowly. If the system contains any solvent it will distill first bringing with traces of moisture also. Allow the solvent to distill out taking care to see that the reflux temperature remains constant and the rate of distillation is a steady drop by drop stream and not a flood. As the solvent in the system is exhausted, the reflux temperature will drop. Moisture now rises through the column and soon becomes evident in the reflux divider. At this stage begin application of vacuum going from 760mm pressure to 100mm pressure gradually and shut off the heating of the reboiler. As the pressure is reduced, the reboiler temperature will begin to fall. When pressure stabilizes at 100mm, begin the heating of the reboiler again till the distillation of moisture just begins. Maintain heating till the moisture is completely removed at which point the reboiler temperature will start rising and the reflux temperature will start falling. Shut off the reboiler heating and bring the pressure to 0-5 mm. Start heating so that distillation just begins. Shut the take off valve till the reflux temperature becomes constant at the lowest level. Begin take off with 50% reflux back and continue till the reflux temperature remains constant. Maintain heating always so that it is just enough to maintain distillation. As the first fraction finishes, the distillation will stop under the minimum conditions and the reflux temperature will drop. Increase the level of heating and repeat the process as for the first fraction and continue till the whole batch is completed.

ANNEXURE 5

SYNTHESES OF FLAVOUR CHEMICALS

One synthesis of an ester is given.
Other esters can be prepared using the same method but varying the quantities in molar proportions:-

ALYL CAPROATE

In a glass flask of a suitable size equipped with a Dean Stark distilling receiver with solvent return tube and stopcock for water release and a large reflux condenser, charge:-

3.18 kilos allyl alcohol
3.18 kilos hexanoic (caproic) acid
3.18 kilos benzene/toluene
0.100 kilos paratoluene sulphonic acid

Reflux until no more water separates. This takes approx 6-8 hrs. Remove acid layer from the bottom.
Change dean-stark receiver to a long direct condenser and distill off the benzene/toluene and excess allylalcohol. Distillation is stopped when the temperature of the vapours reaches 110°-120°. The residue is cooled and 4 litres, of water is added. Neutrallise with powdered soda bicarb under very good stirring. Separate the top layer, wash with water and transfer to a vacuum distillation unit, the yield is 3.6 kilos. BP-75°c at 15 mm.

AROMATIC SYNTHESES

CITRONELLOL

a) E. Citriodora is used after fractionation. The product of fractionation is Citronellal.

b) Lemon grass oil (Contains citral) is used without fractionation.

Both citronellal and Citral after hydrogenation yield citronellol and some dimethyl octanol depending on the control of reaction conditions:-

PROCESS - CITRONELLOL

HYDROGENATION

Charge 45 kilos of lemon grass oil/citronellal fraction and 1.8 kilos of activated Raney Nickel catalyst in an autoclave. Admit hydrogen from a cylinder at 125 PSI and gradually raise the temperature to 100°c. Absorption of hydrogen starts at 80°c. stop heating at this point, since the reaction heat is sufficient to raise the temperature. Do not exceed these temperature otherwise by product formation increases. The reaction is considered to be complete when the theoretical amount of hydrogen has been absorbed. The reaction time is 8-12 hrs depending on the equipment design and activity of catalyst.

After reaction, the oil is allowed to settle, washed with water and taken for fractionation.

AROMATIC SYNTHESES

IONONE 100% FROM LEMONGRASS OIL

Ionone 100% is obtained by condensation of citral and acetone, the condensation product is pseudoionone which upon cyclisation with phosphoric acid yields a mixture of Alpha and Beta ionones.

CONDENSATION

In a 2 litre flask, charge:
310 gm Lemongrass oil
750 gm Acetone
100 gm Barium Hydroxide, 10% solution

Reflux for 2 hours, maintaining the pH at 8.5 Nentralise with a solution of 10% acetic acid and remove acetone by distillation. Wash with 3 x 500 ml sodium chloride 10% solution. Vacuum distill the washed product. The yield is 225-230 gm. BP 143-134.c at 12mm.

CYCLISATION

In a 1 litre flask charge:
300 gm pseudoionone, distilled
30 gm phosposric acid 78%

Heat the pseudoionne to 90°c, interrupt heating and add the phosphoric acid. Reaction sets in at once as indicated by the rise of temperature to 105°c. Maintain at 105-110°c for 2 hours. Cool let settle for 15 minutes, draw off the acid layer. Wash with dilute soda bicarb and fractionate under vacuum. The yield is 250 gm Ionone Alpha and Beta. BP 126-128°c at 10mm.

Annexure 6

FLAVOUR FORMULATIONS

1. APPLE

Vanillin	1
Ethyl Butyrate	5
Ethyl Valerate	10
Phenyl Ethyl Alcohol	0.5
Phenyl Ethyl Acetate	0.5
Citronellol	
Ethyl Butyrate	5
Ethyl Valerate	10
Propylene Glycol	467
	500

2. BANANA

Ethyl Butyrate	10
Iso Butyl Acetate	2
Amyl Acetate	25
Amyl Butyrate	10
Ethyl Heptoate	3
Phenyl Ethyl Alcohol	3
Vanillin	1
Ethyl Vanillin	05
Propylene Glycol	545.5
	600.

3. PINEAPPLE

Ethyl Acetate	5
Ethyl Butyrate	10
Ethyl Valerate	5
Ethyl Acetate	5
Ethyl Heptoate	5
Amyl Caproate	30
Ethyl Caproate	2
Phenol Ethyl Alcohol	2
Vanillin	10
Ethyl Vanillin	1
ALD c-19	10
Propylene Glycol	910
	1000

4. STRAWBERRY

Ethyl Valerate	5
Ethyl Heptoate	3
ALD c-16	20
ALD c-14	5
Ethyl Acetate	3
Ethyl Formate	2
Ethyl Butyrate	5
Amyl Butyrate	5

Vanillin	1
Ethyl Vanillin	1
Propylene Glycol	450
	500

5. BUTTER

Diacetyl	1
Ethyl Butyrate	3
N-Butyric acid	20
Vanillin	0.5
Ethyl Vanillin	0.5
Propylene Glycol	725
	750

FRAGRANCE FORMULATIONS

1. USING ESSENTIAL OILS

(a) E. Citriodora

1.	Phenyl Ethyl Alcohol	100
	Phenyl Ethyl Acetate	15
	Citronellol	25
	Terpineol	20
	Ionone 100%	10
	E. Citriodora	10
	Benzyl Acetate	15
	Musk Xylol	15
	IBCH	10
	Ocimum	5
	Lemon grass oil	3
	Ald c-11	2
2.	Terpineol	100
	Ionone 100%	15
	Methyl ionone	5
	Musk Ambrette	15
	Benzyl Salicylate	20
	Citronellol	30
	Benzyl Acetate	30
	E. Citriodora	15
	Isobornyl Acetate	10
	Ald c-11	1
	Diphenyl Oxide	14

b. OCIMUM

1.	Ocimum	10
	Galaxocide	10
	IBCH	20
	Isolongifolene ketone	10
	Isobornyl Acetate	10
	Dipentene	50
	Terpineol	5o
	Diphenyl oxide	100
	Phenyl ethyl alcohol	80
	Ionone alpha	8
	Ald c-11	2
	Benzyl Acetate	5
2.	Ocimum	15
	Dipentene	45
	Camphor oil	10
	Terpineol	30
	Limonene	5
	Musk xylol	20
	Phenyl ethyl alcohol	30
	Terpenyl acetate	10

C. LEMONGRASS OIL

1.	Lemon grass oil	20
	Limonene	20
	Terpineol acetate	25
	Terpeneol	40
	Dipentene	25
	Musk xylol	15
	Musk ambrette	5
	Diphenyl oxide	10
	Ald c-10	1
	Ald c-9	1
	Lavandin oil	8
2.	Lemon grass oil	50
	Limonene	50
	Dipentene	50
	Citronellol	30
	E. Citriodora	10
	Phenyl ethyl alcohol	100
	Benzyl acetate	15
	Musk ambrette	15
	Ald c-10	2
	Lavandin oil	8

2. USING PRODUCTS OF FRACTIONATION

a) E. Citriodora

E. Citriodora terpenes	20
Dipentene	60
Camphor oil	40
Isobornyl acetate	15
Tepeneol	25
Benzyl acetate	20
Diphenyl oxide	100
Musk xylol	20

b.

Citronellal fraction	10
Citronellol	60
Phenyl ethyl alcohol	70
Diphenyl oxide	30
Ionone alpha	5
Terpineol	30
Ald c-9	1
Ald c-11	1
Musk ambrette	10
IBCH	10
Citronellyl acetate	10

c.

E. Citriodora residue	10
Dipentene	100
Diphenyl oxide	30
Lemon grass oil	10
Pine oil	30

B. **LEMON GRASS OIL**

a)	Lemon grass oil terpenes	15
	Dipentene	70
	Pine oil	30
	Camphor oil	15
	Musx xylol	15
	Diphenyl oxide	30
	Ionone 100%	5
b.	Citral fraction	30
	Limonene	100
	Dipentene	50
	Pine oil	20
	Musk xylol	15
	Musk ambrette	10
	Terpenyl acetate	15
	Phenyl ethyl alcohol	15
	Benzyl acetate	10
	Ald c-8	1
	Ald c-10	1
	Ald c-11	1
c.	Lemon grass oil residue	10
	Dipentene	60
	Diphenyl oxide	100
	Camphor oil	20
	Pine oil	40
	Iso bornyl acetate	15

C. **OCIMUM**

a)	Ocimum terpenes	5
	Citronellol	10
	Phenyl ethyl alcohol	15
	Benzyl salicylate	30
	Ionone 100%	5
	Galaxolide	10
	IBCH	15
b.	Thymol fraction	15
	Lavandin oil	40
	Terpenyl acetate	40
	Geranium oil	20
	Resinoid olibanum	20
	Terpineol	50
	Ionone alpha	5
	Methyl ionone	15
	Citronellol	30
	Ald c-9	1
	Ald c-11	1

c.	Ocimum residue	5
	Dipentene	30
	Diphenyl oxide	60
	Pine oil	100
	Musk xylol	50

C. **USING PRODUCTS OF SECONDARY PROCESSING**

i) **E. Citriodora**	ii) **Lemon grass oil**	iii) **Ocimum**
Citronellol	Ionone 100%	Eugenol
Dimethyl octanol	Methyl ionone	Isoeugenol
Citronellyl formate	Ionone alpha	
Citronellyl acetate	Citronellol	
Citronellyl butyrate	Citral nitrile	
Hydroxycitronellal	Nerol	

a.	Citronellol	20
	Citronellyl acetate	5
	Citronellyl formate	5
	Dimethyl octamol	15
	Phenyl ethyl alcohol	15
	Hydroxy citronellal	50
	Terpineol	30
	Methyl ionone	20
	Ionone alpha	5
	Eugenol	2
	Iso eugenol	8
	Geranium oil	40
	Lavanium oil	30
	IBCH	20
	Galaxolide	30
	Ald c-9	1
	Ald c-11	1
	Benzyl acetate	15
	Ald c-14	5
	Ald c-20	1
	Merol	10

ANNEXURE 7

ESTIMATE OF REVENUE AND EXPENDITURE FOR A MODEL FARM OF 10HA

1. LEMONGRASS OIL

Item	Expenditure(₦)	Revenue(₦)
1.Total Revenue (Essential oil)		1,020,000
2.Fixed Assets		
Field Still	200,000	
Shed	60,000	
Well	50,000	
Total Fixed Assets	310,000	
3.Depreciation(20%)	62,000	
4.Interest charges (25%)	77,500	
5.Current Costs	422,000	
Labour	270,000	
Packing materials	17,000	
Operators	120,000	
Fuel	10,000	
Transport	5,000	
Total Current Cost	561,500	
Gross Profit		458,500

Notes

a. Revenue based on US$12 per kg (and $1=₦ 85 as at May, 1997).
b. Cost of still estimated on basis of local fabrication
c. Labour cost estimates include site preparation, transplanting, weeding and maintenance based on 10ha and 220 working days at ₦300/day and 6 days/ha.
d. The required packing material is galvanized iron drums or polypropylene drums.
e. Two operators assumed on the field still
f. Firewood used as fuel.
g. Yield/ha taken as 100kg.
h. Data provided by National Consultant.

2. **EUCALYPTUS CITRIODORA OIL**

Items			Expenditure (₦)	Revenue (₦)
1.	Total Revenue (Essential Oil)			765,000
2.	Fixed Assets			
	Field Still	200,000		
	Shed	60,000		
	Well 50,000			
	Total fixed Assets	310,000		
3.	Depreciation (20%)		62,000	
4.	Interest charges (25%)		77,500	
5.	Current costs		431,000	
	Labour	270,000		
	Seedlings	9,000		
	Packing materials	17,000		
	Operators	120,000		
	Fuel	10,000		
	Transport	5,000		
	Total Current cost		570,000	
	Gross Profit			195,000

Notes

a. Revenue based on US$4.5/kg (and $=₦85 as at May 1997)
b. Cost of still estimated on basis of local fabrication
c. Labour cost estimates include site preparation, transplanting weeding and maintenance, based on 10ha and 220 working days at ₦300/day and 6 days/ha.
d. The required packing material is galvanized iron drums or polypropylene drums.
e. Two operators assumed on the field still.
f. 6,000 seedlings at ₦15/seedling
g. Firewood will be used as fuel
h. Yield 200kg/ha
i. Data provided by National Consultant.

3. **OCIMUM GRATISSIMUM**

	Items		Expenditure (N)	Revenue (N)
1.	Total Revenue			1,530,000
2.	Fixed Assets			
	Field still	200,000		
	Shed	60,000		
	Well	50,000		
	Total Fixed Assets	310,000		
3.	Depreciation (20%)		**62,000**	
4.	Interest charges (25%)		**77,500**	
5.	Current Costs		**422,000**	
	Labour	270,000		
	Packing materials	17,000		
	Operators	120,000		
	Fuels	10,000		
	Transport	5,000		
	Total Current Cost		**561,500**	
	Gross Profit			968,500

Notes

a. Revenue based on US$18 per kg (and $1=₦85 as at May, 1997).
b. Cost of still estimated on basis of local fabriaction
c. Labour cost estimates include site preparation, transplanting, weeding and maintenance based on 10ha and 220 working days at ₦300/day and 6 days/ha.
d. The required packing material is galvanized iron drums or polypropylene drums.
e. Two operators assumed on the field still.
f. Firewood used as fuel.
g. Yield taken as 100kg.
h. Data provided by National Consultant.

Estimate of Revenne and Expenditure for Model Processing Plant for Ginger.

Items		Expenditure	Revenue
1.	Total Revenue E. Oil (10,200,000) Oleoresin (19,890,000)		30,090,000
2.	Fixed Assets.		
	Plant 19461141		
	building	1,000,000	
	Total	20,461,141	
3.	Depreciation @ 10%	2,046,115	
4.	Interest charges @ 25%	5,115,285	
5.	Current costs.	7,310,800	
	Materials	6000,000	
	Solvent	85,000	
	Operators (2)	72,000	
	Store keeper	54,000	
	Boiler Techn.	64,800	
	Packing materials	850,000	
	Fuel	180,000	
	Transportation	5,000	
	Total Cost	14,472,200	
	Gross profit		15,617,800

Notes:

a. Price of Ginger oil and Ginger Oleoresin depends on the quality of Ginger used and depending on the flavour and pungency, the price can vary from US$30 to Us$50 for ginger oi and from Us$15 to US$30 for ginger oleoresin. For the purpose of this calculation the price of oil has been taken at US$30 and ginger oleoresin at US$18. Pilot Plant Trials have not yet been taken and as such the actual quality of ginger oil and ginger oleoresin has not yet been determined.

b. The required packing material is aluminium bottles

c. The yield of ginger oil has been taken at 2 percent and that of oleoresin at 6.5 percent

d. A plant of this type requies an exteranl boiler for which diessel type fuel oil is required

e. The working and capacity of the plant is assumed to be such that it can service the produce of 100 ha.

f. Price of dry ginger fluctiates from ₦30/kg to ₦60/kg during the course of the year. For the purposes of this calculation, the price at the begining of the season is taken to be the cost price at which ginger will be procured for processing.

g. An exchange rate of US$1 to ₦85 is taken as at May 1997

h. Data has been provided by National Consultant.

Estimate of Revenue and Expenditure for Model Processing Plant for Chillies.

Items		Expenditure		Revenue
1.	Total Revenue Oleoresin (only)			15,300,000
2.	Fixed Assets			
	Plant	19,461,141		
	Building	1,000,000		
	Total Fixed Assets	20,461,141		
3.	Depreciation		2,046,115	
4.	Interest charges		5,115,285	
5.	Current Costs		3,310,800	
	Materials	2000,000		
	Solvent	85,000		
	Operators(2)	72,000		
	Store keeper	54,000		
	Boiler Techn.	64,800		
	Packing Material	850,000		
	Fuel	180,000		
	Transportation	5,000		
	Total Cost		10,472,200	
	Gross Profit			4,827,800

Nates:

a. The price of Chillies oleoresin depends on the quality of chillies used and depending on the purgency (capscacin) and colour content and can vary from US$18-US$30/kg. For the purposes of this calculation, price has been taken at $18 because pilot plant trials have not yet been taken as such the actual quality of chillies oleoresin based on local chillies has not yet been determined.

b. The required packing material is alliminium bottles

c. Yield of oleoresin from dry chillies is taken at 10%

d. A plant of this type requies an external boiler for which diessel type fuel oil are required.

e. The working and capacity of the plant is assumed to be such that it can process the produce of 100 ha.

f. Price of dry chillies fluctinalis from ₦20/kg - ₦50/kg during the course of the year. For the purposes of this calculation, the price at the begining of the season is taken to be the cost price at which chillies will be procured for processing.

g. An exchange rate of US$1 to ₦85 is taken as at May 1997.

h. Data has been provided by National Consultant.

* Total Value Realisation in ₦ by the Farmers from 10 ha.

Crop	'91 Yield/ha in tonnes	'93 Yield/ha in tonnes	Farmgate '97/price in ₦ per tonnes	Total value in ₦ realised by farmers/ha	Total valu realizatio in ₦ from 1 ha by th farmers
1. Maize	1.10	1.34	4650	6231	62,310
2. Sorghum	0.68	1.06	4920	5215	52,150
3. Millet	0.68	0.93	3225	3000	30,000
4. Rice	1.44	1.38	6255	8632	86,320
5. Cowpea	0.41	0.49	7170	3514	35,140
6. Ground Nut	0.53	0.80	7005	5604	56,040

ANNEXURE8

Economic Background to Production of Essential Oils in Nigeria.

The Nigerian econony is not stable, low inflation economy which encourages the farmers and entrepreners to develop businesses with medium and long term time frames. It must be emphasised that the creation of an essential oils and oleoresins industry, especially one requiring systematic cultivation of aromatic plants is a medium and long term operation.

The nature of contracts with international essential oil traders in London, Hamburg and New York require regular delivery. It is not possible to cease production if market conditions or changes in domestic prices lead to temporary loss of profitability.

Nigeria has succeeded in bringing down its inflation rate in 1996 and 1997 after 4 years of very high inflation e.g from 72.8% in 1995 to 20-30% in 1997 as for the budget estimates, reported by Central Bank of Nigeria. It is hoped that the value of Naira will eventually be adjusted to reflect the loss of international competitivesness due to high rates of inflation during the last three years.

As such to retain relevance, all calculations of input costs and output values have been made in US dollars so that the actual Naira values can be realistically recalculated at any future date. Except for chillies and ginger, these is no reliable data available for the others plants being considered in this report. As per Central Bank of Nigeria's 1995 report, the price data regarding ginger is an under:-

Ginger (Peeled)
Price per tonne in Naira.

1991	-
1992	1995
1993	10,745
1994	34,906
1995	40,342

The massive increase between 1993 and 1995 was caursed by the adjustment of Naira's rate of exchange against the dollar. Ginger prices in April/May 1997 were in the range of ₦40-50,000 per tonne. This price remains very competitive and the same is demonstrated by exports of peeled and split Ginger to the extent of an average of 800-1000 tonnes per year during 1992-96, valued between ₦10-20 million. In 1995, Nigeria exported some 3000 tonnes of Ginger to European markets.

Chillies.
Price per tonne in Naira.

1991	-
1992	-
1993	75,832
1994	124,970
1995	131,300

The price increase between 1993 and 1995 is less than that for Ginger (only 72% against 400% for Ginger). The estimated exports of chillies from Nigeria are of the order of 100-200 tonnes per annum. The regular exports demonstrate the competitiveness of Nigerian chillies for the purpose of oleoresin extraction. This will be enhanced by the proper classification of local varieties in terms of colour and pungency which will enable the Pilot Plant to optimize its raw material procurement and processing parameters.

The selection of correct varieties will enable the farmers to grow the most suitable varieties of Ginger and chillies. The more difficult task is to implement a programme of systematic cultivation of lemon grass and citriodora and establishment of field shells for the distillation of their oils.

Borrowing rates: Entrepreneus who borrow from banks to finance expenditure on field stills, planting material, oil and oleoresin distillation and extraction units may realistically assume a rate of 22-25% per annum based on current prime rates.

Potential user industries in Nigeria: Immediate sales in the domestic market will be extremely difficult. The processed foods industry in very small due to the prices of end products being too high for the average consumer. The multinational companies operating in the soaps, comestics, toileteries and food areas tend to import their requirements from international fragrance and flavour companies.

The Exchange Rate: The exchange rate of the Niara against the dollar was adjusted sharply downward in 1994. It has since remained should at 80-85 Naira per dollar. There has been no adjustment for the high rates of inflation during 1994, 1995 and 1996 and there has been no adjustment in 1997 in terms of the US dollar's strenght against the Japanese Yen and the European currencies.

Irrespective of the currency adjustments made in 1997-2000, the experts are confident that by working in US dollars, the calculations made in the report will remain valid for the next few years.

The positive cost benefit analyses made in the report should encourage the potential entrepreneurs to establish new industries in the area of essential oils and oleoresins with the technical assistance and support of the project staff at the National

Institute for Pharmaceutical Research and Development (NIPRD). However specific inputs need to be provided to enable the Nigerian entrepreneurs to access the international market which is already well supplied by existing sources.

ANNEXURE 9

Recommended Management Structure Required to Support the Demonstration - cum-Production Pilot Plant.

1. The Pilot Plant Project Team: The technical sophistication of the pilot plant and its potential to make the NIPRD a regional centre of excellence and expertise demands that a dedicated and professional team should be created to operate the pilot plant and take charge of its raw material procurement and marketing requirements.

2. The Pilot Plant Project Manager: This person should be responsible for managing all technical and commercial aspects reporting directly to the Director General and Chief Excutive Officer of NIPRD. The specific responsibilities should include:

- Production and maintenance
- Procurement and extension
- Cost accounting and agricultural costing
- Marketing and Export sales
- Quality control.

3. Operations: The Pilot Plant cannot achieve process standardization and establish comprehensive operating parameters for essential oil and oleoresin production if it operated on an intermittent basis. It must be used on a regular basis as a demonstration cum production unit so that future invesments by entrepreneurs or by farmers in field stills can be based on the pilot as a model for determining costs, yields and profits. As a consequential benefit, it will develop the capacity to become a regional centre where interested scientists and entrepreneurs can come for hands on training. This is in turn only possible if it functions on a regular basis. Continuous generation of process technology will be a required capability of such a centre.

   This makes it essential that the pilot plant be staffed with the most capable staff who in addition to operating the pilot plant wil also be eventually be responsible for training of personnel who come to the regional centre for this porpose.

4. Production, Maintenance and Fabrication Section: This requires a Production Manager supported by a Maintenance Manager who in turn will be in charge of the Maintenance cum fabrication Workshop. The Production Manager will be in charge of all aspects of Production Sceduling, yield, operating efficiency and maintenance.

5. Procurement and Extension: The Procurement Manager working with the Extension Manager will be responsible for:-

- Purchase of raw materials from merchants or collectors mostly ginger and chilles.
- Development of groups of farmers to grow and distil

lemongrass, citriodora and ocimum

- Development and multiplication in the nursery of desired varieties required for cultivation, particularyly Ginger and Chilli varieties with best yield and organoleptic qualities.

The supply of raw material to the pilot plant for trial production would be the responsibility of the Procurement Manager. The Extension Manager will have under him two specialists - one to propagate cultivation and the second to develop and install field stills.

6. Cost Accounting and Agricultural Costing: It is essential that the Pilot Plant Manager has accurate daily, weekly and monthly cost data on the project, operation and that accurate monthly, quaterly and yearly budgets are established and closely monitored. A cost accountant should be attached to the Pilot Plant to ensure that cost and revenue paremeters are correctly established and expenditures are tightly controlled.

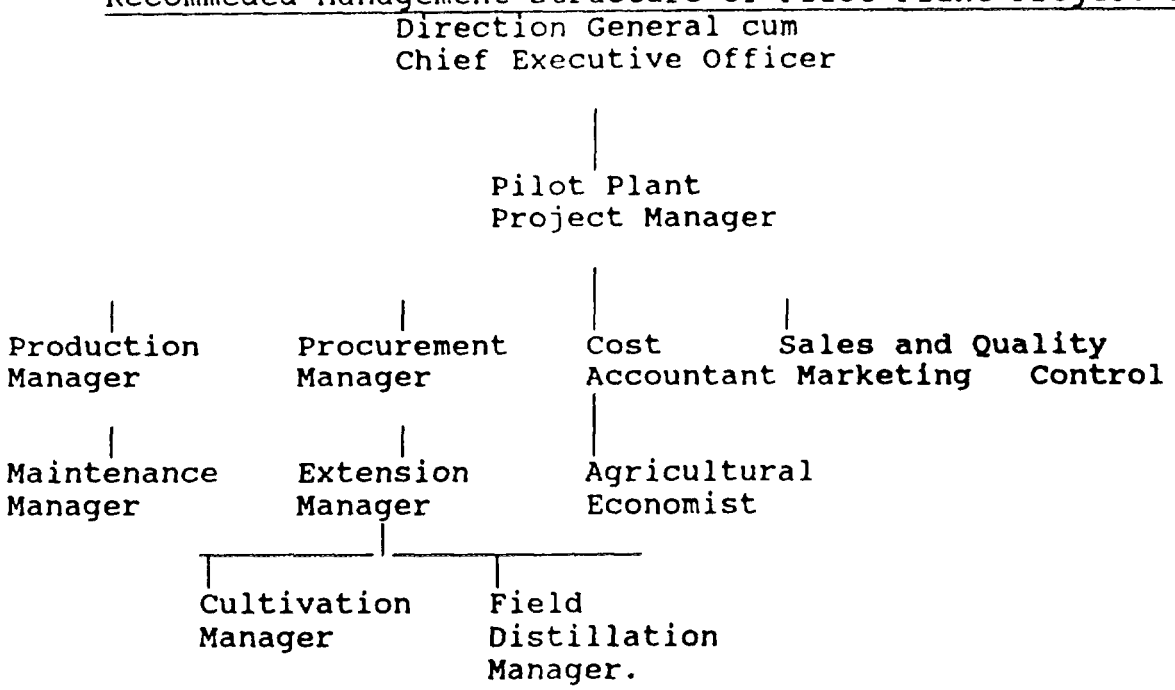
In addition and Agricultural Economist should be attached to the Pilot Plant on a part time basis. He would be responsible for costing the recommended packags of practices for the suitable varieties of crops particularly for Ginger and Chillies where improved yield and post harvest practices will have great effect on the rates of return.

7. Marketing and Export Sales: This person with long term responsibility for Exports, is required to ensure that potential Nigerian users are contacted along with internationl dealers and brokers in London, Hamburg and New York. He will have to estimate the volumes available for sale and assist the entrepreneurs in marketing in domestic as well as export markets.

8. Quality Control: A separate department for the quality control of the products of the Pilot Plant and the field stills should be established. It should be equipped to check the materials purchased and produced to be in accordance with the required specifications. On the basis of average results such a quality control department should be able to define the characteristics of the various varieties of Ginger and Chillies in terms of essential oil content, odour, taste and physiochemical characteristics such as specific Gravity, Refractive Index, Optical Rotation alongwith colour and pungency levels.

9. Staffing Requirement: The Pilot Plant can only operate successfully if it is managed as a project operated by a dedicated team of professionals as set out in the preceeding paragraphs. The personnel requirement described is not excessive in view of the fact that the Pilot Plant has the full potential to generate sufficient revenue to be self sufficient and a profif centre.

Recommeded Management Structure of Pilot Plant Project Team:



A NOTE ILLUSTRATING THE OPERATION OF THE PILOT PLANT AS A DEMONSTRATION CUM PRODUCTION UNIT.

It is the purpose of this note to examine the economic and financial feasibility of operating the Pilot Plant as a demonstration cum Production Unit.

The plant would convert the ginger to ginger oil and oleoresin and Chillies to Oleoresin with the proviso that the correct varietis of Ginger and Chillies are selected and suitable quality raw materials are purchased to enable the Pilot Plant to achieve optimum operating parameters.
The plant has a charge capacity of 150kg of raw material and could take 2 charges on a 3 shift basis per day. It could be operated either for 100 days or 200 days per year.
The material required for annum on the basis of 200 working days would be:-
Ginger (Crushed) 30,000Kg
Chillies (crushed) 30,000Kg

The material required per annum on the basis of 100 working days would be:-
Ginger (crushed) 15,000 Kg
Chillies (crushed) 15,000 Kg
The cost of these materials would be:-
Ginger 30,000 Kg @ ₦40,000 per M/T = ₦1,200,000
15,000 Kg @ ₦40,000 per M/T = ₦600,000
Chillies 30,000 Kg @ ₦140,000 per M/T =₦4,200,000
15,000 Kg @ ₦140,000 per M/T =₦2,100,000
The operating costs are calculated as under:-

	Operation for 100 days	Operation for 200 days
Fuel	$2500	$5000
Solvent	$600	$12000
Labour	$4000	$6000
Transportation	$3000	$5000
Packaging	$4000	$8000
	$19,500	$36,000

Note: These are very preliminary figures and will be corrected when the Pilot Plant becomes fully operational.

Total Costs in Naira (Exchange Rate $1 = ₦85)

1. 100 days operation

	₦
Material	2,700,000
Other Costs	1,657,500
Total	₦4,357,500

2. 200 days operation

	₦
Materials	5,400,000
Other Costs	3,060,000
Total	₦8,460,000

Receipts can be calculated on the following basis:-

	Yield	Price/Kilos
Ginger	2%	US $30.00
Ginger oleoresin	6.5%	US $18.00
Chillies	10%	US $30.00

The revenues from the 100 days operation of the Pilot Plant is calculated as follows:-

1. Ginger oil 300Kg @ USD 30 = USD 9,000
2. Ginger Oleoresin 1050 Kg USD 18 = USD 18,900
3. Chillies oleoresin 1500Kg @ USD 30 = USD 45,000

Total = USD 72,900

and the yield from the 200 day operation is exactly double i.e. USD 145,800.

Total cost and revenues in Naira are as under:-

100 days operation	₦
Revenues	6,196,500
Costs	4,357,500
Total Surplus	N1,839,000
200 Days Operation	
Revenues	N12,393,000
Costs	8,460,000
Total Surplus	3,393,000

There is therefore little doubt that the Pilot Plant can be operated as a Demonstration cum Production Unit. There is sufficient margin to tolerate a 10% ± error in calculation which only proves the feasibility.

ANNEXURE10

RAW MATERIALS REQUIREMENT BY SECTOR

It was only three (3) days before the end of the mission that the Team Leader discovered the existence of the Raw Materials Research and Development Council (RMRDC) Lagos and an extremely detailed and useful report.

DR. O.A. ARIBISALA,
"Raw Materials Revolution and Impart on Industrialisation in Nigeria" Mednet LAGOS 1993 PP. 352, which studies systematically the annual needs of some product sectors in terms of annual needs of key flavours, essential oils, colourants, gum, waxes, resins etc:-

P.108 FOOD, BEVERAGE and TOBACCO Sector
Shows Local requirement of 6.5 tonnes of Eucalyptus oil with supply at only 1.5 tonnes.

P.138-143 COSMETICS AND TOILETRIES shows
109 Tons of Essential Oils
167 Tons of Fragrances
50 Tons of Turpentine derivatives

P. 158-171 EXCIPIENTS (ADDITIVES)
400 KG CAPSICUM OLEORESIN
6 MT PINE OIL (Household Cleansers)
2 MT THYMOL (Derived from Ocimum)

P.173-174 SOAP and DETERGENTS
10 MT Perfumes
175 CHEMICALS USED IN PRIMARY PAPER MILLS
Usage of Rosin is shown at 650 MT with local supply at only 109MT but there is no explanation of the end use of TURPENTINE derived locally through the processing of PINE OLEORESIN to Rosin and Turpentine. It is apparently NOT used in the Paint Industry.

CONCLUSION

Dr. ARIBISALA would have been a superb resource person for the Team leader and Marketing Consultant had either the National Consultant or National Institute for Pharmaceutical Research and Development, Abuja been aware of her existence and Raw Materials Research and Development Council (RMRDC) of which she was DIRECTOR-GENERAL in 1993, but has since left RMRDC on its move to Abuja.

ANNEXURE 11

PACKING MATERIALS: AVAILABILITY AND COSTS

The initial drums and aluminium bottles requirements over the next 3-5 years will be modest based on 200/220 litre drums and 10/25/30 kg Aluminium Bottles. These drums from companies like Van Leer, Blagden, UK and aluminium bottles from companies like Tournaire, Grasse, France will have to be imported empty if there is no fabrication facility available in Nigeria. The Ivory Coast imports drums from France for its Lime and Bergamot exports. The NIPRD will require these packing materials as Pilot Plant becomes fully operational and steps must be taken to import these or procure them from Lagos dealers. At that time the packaging cost data provided in the report should be recalculated.

ANNEXURE 12

A NOTE ON THE TRANSPORT SECTOR IN NIGERIA

The transport fleet of medium and heavy trucks (3-20 tonnes) is a rapidly deteriorating asset and very few new truck chassises have been imported since the introduction of the dual exchage rate policy in 1995.

Transport operators emphasize that they cannot meet the new Naira Costs of spare parts, batteries and tyres. The compensation for them is only the very low cost of fuel. This cannot however compensate for the rundown in the operating and maintainance balance of the truck fleet over the six years (1995-2000)and it is likely that truck availability during periods of peak harvest season demand may well cause problems for the movement of key agricultural produce like ginger and chillies.

The movement of drums of extracted material to various cities for use by domestic consumers or to Lagos for export shipment will not be such a serious problem as the value\weight ratio of essential oils and oleoresins is always extremently high as compared with unprocessed agricultural produce.

ANNEXURE 13

FOREIGN EXCHANGE MANAGEMENT AND NAIRA/US DOLLAR CONVERSION RATES 1991 -1997

1. A recent Occasional paper by the International Monetary Fund (I.M.F) has discussed the operation of stablisation policies in Nigeria:-
GARY MOSER, SCOTT ROBERS AND REIHOLD Van Til
"Nigeria: Experience with Structural Adjustment 1986-1994"
The paper does in fact discuss the reforms of the system in 1995, but not the likely medium or long-term effects of the new policy in terms of Naira US Dollar exchange rate, which is critical for export industries.
2. The Foreign EXCHANGE Market was partially deregulated in early 1995 when the government and the Central Bank of Nigeria (CBN) introduced a dual exchange rate system through Autonomous Foreign Exchange Market (AFEM), which is managed by CBN intervention. The official rate of exchange of ₦21.9960/USD is retained but from 1995 to date (May, 1997) the AFEM (The effective rate for normal commercial import costs or the coversion of export receipts has fluctuated between ₦80-87/USD and is currently around ₦85/USD.
3. It is important to note that this is not a fully deregulated rate and there has been no effective compensation for post 1995 domestic inflation. There is also a danger that unless further downward adjustments occur during 1998-2000 that exportable products derived from leaf or spice crops will find that rates of return to farmers in comparision with alternative food crops sold only in the domestic market will decline and both cultivation and processing of these Essential oil and Oleoresin crops (including other potential items such as Papaya, Black pepper and both cultivation and processing of these essential oil and Oleoresin crops (including other potential items such as Papaya, Black Pepper and Pine Oleoresin) will deteriote. Entrepreneurs will find they are unable to process and export profitably matching international product prices in European markets. Finally the activities will decline rapidly without downward adjustment of the Naira. It is the problem of delayed currency adjustment which has led us to show all actual and projected costs and receipts in US Dollars to allow for recalculation as the Autonomous Foreign Exchange Market (AFEM System) adjusts 1998-2000.

N.B. This Annexure is based on a description of Foreign Exchange Management in "Annual Report and Statement of Account Year Ending 31st December, 1995. Central Bank of Nigeria LAGOS, 1996. Page 6.
Latest developments will soon be available in the Central Bank of Nigeria's 1996 Report to be published in May/June, 1997.

ANNEXURE 14

PARTIAL LIST OF PUBLICATIONS CONSULTED.

- Annual Report and statement of Accounts 1995
  Centrla Bank of Nigeria.
  April 1996, LAGOS
  (The 1997 Report is currently being prepared).
- Exportable Production Map
  Nigerian Export Promotion Council
  1994 (List of States producing Ginger and Chillies).
- Journal of Pharmaceutical Research and Development (NIPRD)
  Volume I, Number I, July, 1996.
- O. EKUNDAYO, I. LAAKSO and R. HILTUNEN:
  "Composition of Ginger (Zingiber Officinal Roscoe) Volatile Oils from Nigeria".
  Flavour and Fragrance Journal
  Volume 3, 85-90 (1988)
  (This is an important article for Nigerian exports of Ginger oil and Ginger Oleoresin as it is optimistic about the FLAVOUR CHARACTERISTICS)
- O. EKUNDAYO,
  "Essential Oils VIII. Volatile Constituents of the leaves of OCIMUM VIRIDE" (OCIMUM GRATISSIMUM VIRIDE: HIGH PERCENTAGE THYMOL)
- T.O.E. Ekpendu, A.A. Adesomoju O. Ekundayo and J.I. Okogun, I. Laakso.
  "Constituents of the Volatile Oil of MITRACARPUS SCABER ZUCC.
  FLAVOUR and FRAGRANCE JOURNAL, Vol. 8, 269-271 (1993)

  "Medicinal Plants in a Developing Economy".
  Proceedings of the Nigerian Society of Pharmacognosy 1990.
  edited by ALAOESANMI A.J., ELUJOBA A.A., ADESANYA S.A. and AGBOECHI C.A.
  (This conference contains interesting papers by C.O.N. Wambebe and a long paper on Useful Tropical Plants in Health Delivery by J.C. OKAFOR).
- An earlier set of papers were published in 1986 by the University of Ibadan Press.
  "The state of Medical Plant Research in Nigeria"
  edited by A. SOFOWORO.
- Budget of Economic Growth and Development, by
  General Sani Abacha,
  17th January, 1997. (Abuja 1997)
  (This pamphlet summarises main economic trends in the economy up to the end of 1996 and gives basic data which will be developed fully in the 1996 report of the Central Bank of Nigeria).
  DR. O.A. ARIBISALA,
  Raw Materials Revolution and Impact on Industrialisation in Nigeria".
  Mednet LAGOS 1993.
  (A very detailed study on volume use of essential oils, oleoresins, resin and flavour, fragrances and perfumes in all the major end-user industries with some figures on domestic production of some of our products).