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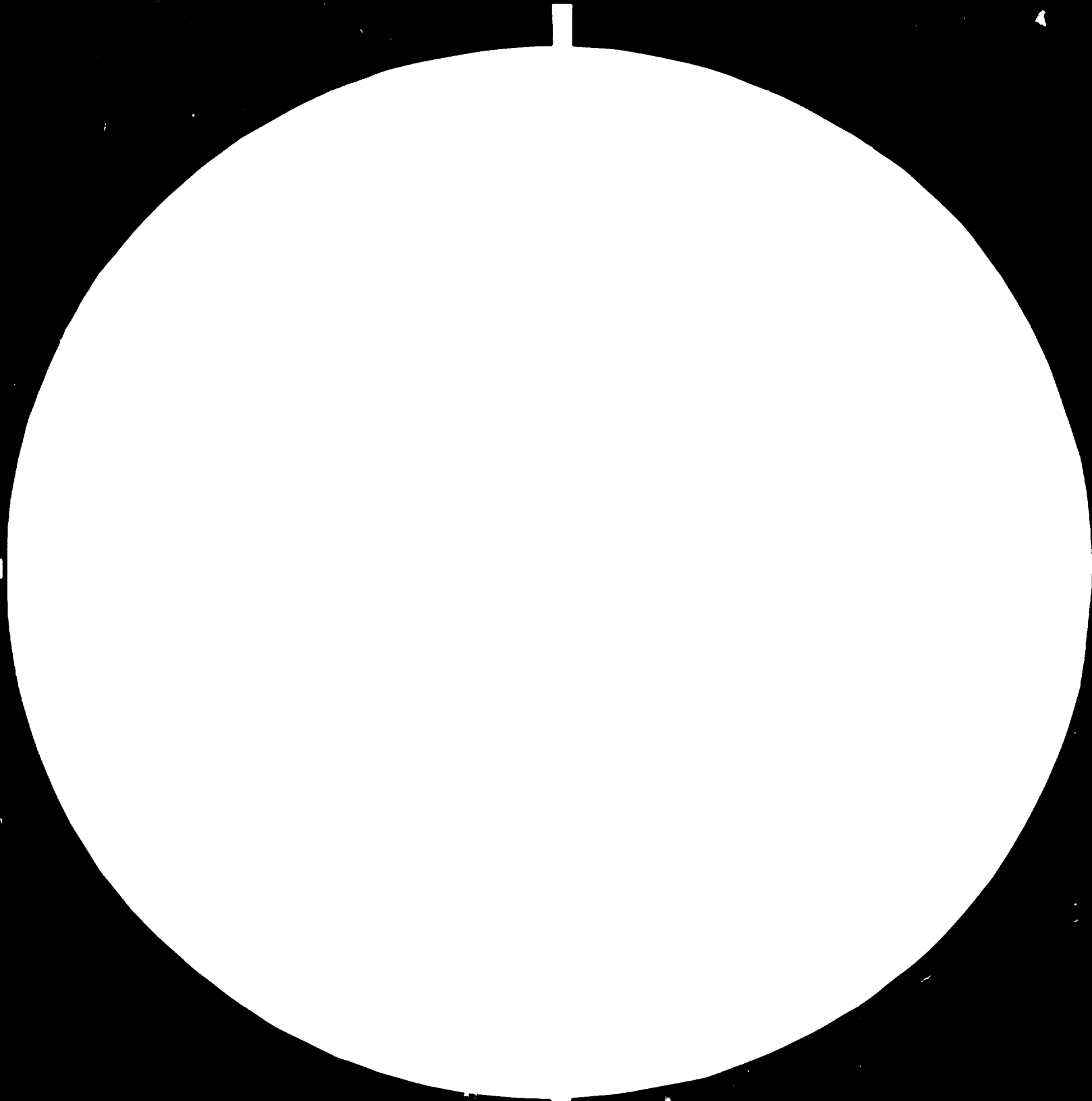

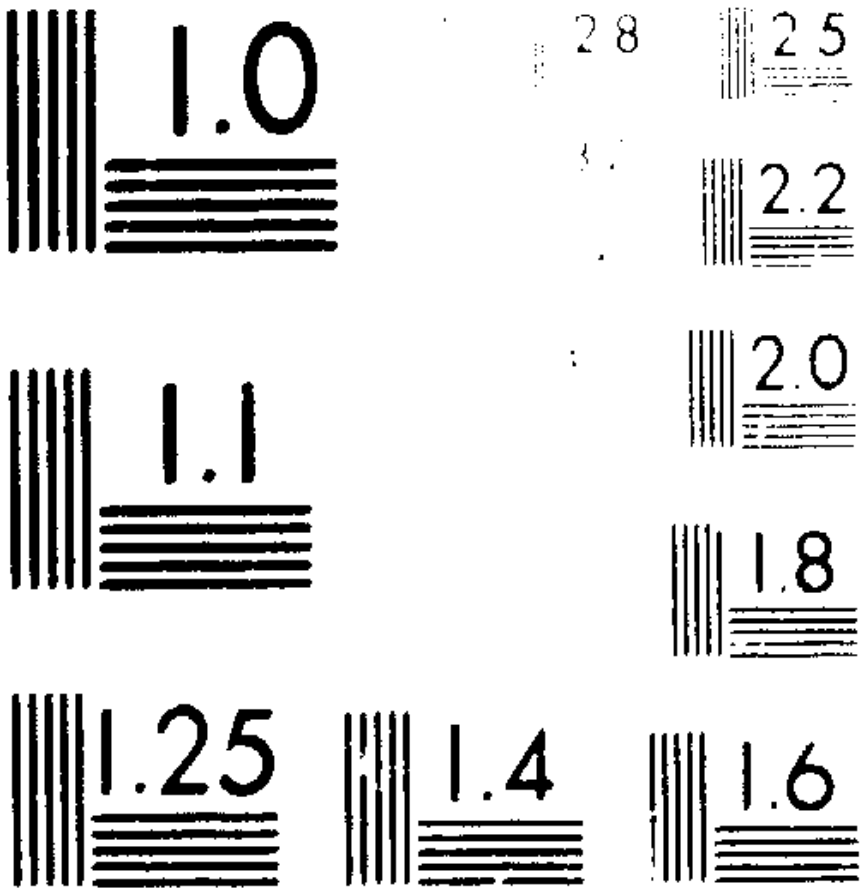
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DP/ID/SER.B/323
10 December 1981
English

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ASSISTANCE TO THE INDUSTRIAL SURVEY AND PROMOTION CENTRE (ISPC)

Studies on medicinal and aromatic plants in Kenya

DP/KEN/74/007

KENYA

Terminal report*

Prepared for the Government of Kenya
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Akthar Husain,
specialist in medicinal and aromatic plants

United Nations Industrial Development Organization
Vienna

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ACKNOWLEDGEMENT

The author wishes to express his sincere thanks to the authorities of Industrial Promotion Department of the Ministry of Industry in Kenya and specially Mr. Mwencha, Principal Projects Officer, for extending excellent help and co-operation during the course of this study.

He is specially grateful to Dr. S.M. Kiruthu his counterpart for his hard work and help in carrying out the survey and collection of necessary data.

Grateful thanks are also due to other experts of UNIDO specially Dr. A.D. Monteiro, Prof A.D. Bohra and Mr. S.S. Gill for their valuable help and guidance in carrying out the work.

The author also wishes to acknowledge the help and co-operation extended by various scientists in the department of Pharmacy, Biochemistry, Chemistry and Veterinary Sciences of the Nairobi University providing necessary information. He is specially indebted to Dr. Mugo of Biochemistry Department and Dr. R.M. Munau of Chemistry Department for sparing their time for discussion and alanysis of plant samples.

He would like to express his grateful thanks to Mr. A. Nganga and Mr. P.G. Otieno of National Agricultural laboratories, Nairobi, for providing necessary information and published data which was very useful for this study.

Hewould also like to thank the authorities of UNIDO and specially Dr. A. Tcheknavorian, Chief of Chemical Industry division for giving him opportunity to work in Kenya.

In the end the author would like to offer his sincere thanks to Mrs. Dias who was responsible for typing and preparation of the manuscript.

INTRODUCTION

Inspite of tremendous development in the field of synthetic drug chemistry and antibiotics, higher plants still constitute as one of the main sources of drugs all-over the world. More than 25% of all the formulations prescribed in modern medicine today contain at least one or more constituents from plants. Exact data from all the countries is not available, but a study carried out in U.S.A. in 1973 indicated that 25.2% of all the prescriptions inssued in that country contained one or more active constituent from plants. During that year American public paid more than 3 billion collars for the cost of plant drugs alone. It was estimated that out of 76 active constituents of plants commonly prescribed in U.S.A. only 7 were obtained from synthetic sources. In addition to pure compounds more than 96 crude extract of plants were also commonly used in the prescriptions. The condition in other developed countries of Europe and developing countries of Asia, Africa and South America is not different than U.S.A. Infact in these countries the use of plants drugs is much more, because a number of these countries still use traditional systems of medicine which derive more than 90% of their medicaments from plants. During the last 10 years there has been a general trend in all the countries of the world to switch over to medicines from natural sources which are considered safer because of fewer side effects as compared to synthetic chemicals and antibiotics. As such the demand for medicinal plants and their active constituents has been increasing even in the developing countries. Authentic data of world trade are available only for the year 1976. According to United Nations World Trade Annual, the value of import of plant seeds, flowers, and parts of plants primarily used for medicine, perfumery, insecticidal or fungicidal purposes in OECD countries (Organisation of Economic and Commercial Development) increased from 52.9 million dollars in 1976 to 71.2 million dollars in 1971 and to 217 million dollars in 1976. Because of escalation in price and further increase in production the value would

be well over 300 million dollars today. This does not include the import to communist countries of U.S.S.R. and other East European countries which are major consumers of medicinal plants. Similarly the import of active constituents which includes alkaloids, enzymes, glycosides, harmones and extracts to OECD countries amounted to 700 million dollars in 1976. The export of active constituents of plants by the OECD countries was 752.5 million dollars in 1976. Taking the escalation in prices and import in Communist countries the world trade in adtive constituents and crude extracts of plants would be well over 1000 million dollars today.

In addition to medicines, plants are also the major raw materials for essential oils and resinoids used in perfumery, cosmetic and flavours industry. About 10 years ago it was considered by certain quarters that ultimately most of the perfumery and flavour compounds would be obtained from synthetic sources. However, the experience dueing the last five years has shown that perfumery chemicals from plants are preferred and the cost of synthetic materials has increased because of considerable increase in cost of Petroleum products. According to international trade statistics, total trade in essential oils and resinoids was approximately 4500 to 5000tons valued at 425 to 500 million dollars in 1976. With considerable increase in prices of all products, the value of world trade today must be well over 700 to 800 million dollars.

The demand for such products in he world is increasing specially because of improvement in standard of living and development of perfumery and cosmetic industries in the third world.

Preliminary studies carried out by Department of Pharmacy, Biochemistry and Chemistry at Nairobi University had indicated that Kenya has a sizable potential of indigenous raw material which could be utilized for setting up industries based upon medicinal or essential oil plants. The studies carried out at Pharmacy Department had also indicated that because of its favourable agroclimate Kenya is quite suitable for introduction and cultivation of a large number of medicinal and aromatic plants which already have established use in pharmaceutical, perfumery and cosmetic industry.

It was on this basis that Industrial Promotion Department of the Ministry of Industry considered it worthwhile to carry out a study regarding the possibility of the use of indigenous raw materials for industrial purposes.

Original job description envisaged only initiation of scientific survey of medicinal plants. However on the basis of discussion with the authorities of the industry department, it was decided to carry out such studies which would not only help such a survey, but would lead to definite industrial project in Kenya. (Annexure I). As such the job description was modified and revised and the study was undertaken with the primary objective to identify viable industrial projects which would ultimately lead to setting u industries based upon raw materials available from wild palnts or those plants which can be profitably cultivated in Kenya. The study was carried out with special refereene to present and future demand of phamaceuticals or essential oils with reference to their use in the world. A list of most important active constituent derived from plants and essential oils is given in Annexure IV, V and VI.

METHOD OF STUDY

In order to find out the existing raw materials, discussion was held with various scientific groups which have carried out such studies. In addition actual field survey of main agroclimatic zones in the country was also carried out to find out those plants which have established use either in modern medicine or essential oil industry. Some of these plants were alanysed chemically with the help of chemistry department of Nairobi University and future guidelines were also given to scientists for carrying out survey for finding out new plants of industrial value.

World demand of medicinal plants and essential oils was found from published literature by International Agencies.

Assessment of requirement of pharmaceutical and perfumery industry was carried out by verbal discussion by the representatives of various industries. Agroclimatic study was carried out by actual field survey of main agroclimatic zones, discussion with various agricultural research station scientists and published climatic datas.

Status of research and development was studied by visit to various research institutions in the country who are involved in research on plants.

The programme of work and list of people and institutions contacted is given in Annexure II and III.

PROJECT FINDINGS

1. Existing Raw Materials

A/ Medicinal Plants

Following plants which are used in modern medicine or which can be exported for pharmaceutical purposes are available in Kenya. Based upon their importance and available quantity their potential for commercialization is discussed below.

i) Cinchona sp: Kenya is one of the main countries in Africa producing cinchona bark. The plant is cultivated by only one British company Messrs. Brookbond Leibig Ltd., one of the main tea planters in Kericho area of Kenya. The bark is being exported to U.K. and Belgium where cinchona alkaloids are produced.

The firm refused to give actual data regarding production and quality of bark. However, on the basis of export data obtained from the Department of Customs and Exise annual production varied from 449 to 565 tons annually during the last three years. As such at least 500 tons is available annually for processing. This would easily support an industry with a production of at least 25 tons of cinchona alkaloids (with a minimum average recovery of 5%, although Kenya bark is supposed to contain more than 6% alkaloid). This would give an annual turn over of approximately 37 to 50 million Kenya Shillings. (Price of cinchona alkaloid has been varying from 1500 to 2000 Kenya Shillings during the last three years).

Cinchona bark contains more than 20 alkaloids of which Quinine and Quinidine are commercially important. The other two important alkaloids which have commercial importance are cinchonine and cinchonidine. Cinchonidine is used as an antimalarial drug in form of hydrochloride or sulphate while quinidine is used as a cardiac depressent (antiarrhythmic agent). A large portion of quinine is used for flavouring soft drinks in U.S.A. and U.K. The demand of quinine and quinidine is stable and expected to grow in future specially because of increased incidence of malaria in Asia and Africa and extensive use of quinine in soft drinks and tonic waters.

ii) Sisal (Agave Sisalana): Kenya is one of the main sisal producing countries in Africa and there are a large number of good sized sisal estates. Kenya sisal contains a steroidal sapogenine called Hecogenine. Hecogenine is a starting material for synthesis of a number of steroidal drugs mainly corticosteroids. In fact for synthesis of contico steroids Hecogenine is considered superior to Diosgenine because of its special chemical structure. A few years ago production of crude Hecogenine was started from sisalsludge which is a byproduct of sisal fibre industry in some estates in Kenya. One of the big states where Hecogenine was produced has given up production as the estate has stopped planting Agave Sisalana. which is rich in Hecogenine and have switched over to planting of hybrid agave which is very poor in Hecogenine.

However, there are a large number of other estates in Taita Hills, Thika and Nakuru area which are only planting A. sisalana and there is need to start at least 3 to 4 units in different states each producing 10 tons of pure hecogenine. Each unit would easily have a gross

turnover of at least 3 to 4 million shillings (Average price of Hecogenine being K.Shs. 300 to 400 per kg.) However the entire processing should be done in Kenya and the material should not be exported in a crude form. Hecogenine has considerable demand in international market and at present it is being produced only in Tanzania. In fact some of the fastest selling corticosteroid preparations marketted by Glaxo laboratories are based upon Hecogenine as the basic raw material.

Corticosteroids are some of the most important medicinal compounds used today throughout the world. These are used to treat a large number of disorders which includes rheumatoid arthritis, rheumatic fever, collagen diseases, ulcerative colitis, certain cases of asthma and a number of allergic diseases affecting skin, eyes and the ears.

iii) Stramonium (Datura Stramonium): It is one of the most widely distributed plant in Kenya. The plant is found growing wild on road side in the Rift Valley and the entire Western Kenya. It is also the most common weed on cultivated fallowlands. The leaves of stramonium contain Hyoscymine (70 to 75%) and Hyoscine (25-30%) both of which are used in modern medicine. However, because of low alkaloid (0.4 to .5%) content D. stromonium cannot be used for alkaloid production and the main source of tropane alkaloid in the world today are Egyptian henbane (Hyoscymus muticus) and Duboisia sp, which have total alkaloid content of 1.5 and 3.0% respectively.

The main use of stramonium leaves today is in the form of crude extract or tinture. This is still used to a significant extent in prescription employed for treatment of intestinal and respiratory disorders. Attempt can be made to collect the leaves and export them either as dried leaves or concentrated crude alcoholic export. There is considerable potential for export of extract to Europe and Middle East.

iv) Aloes (Aloe secundiflora): Kenya has a fairly large amount of wild growth of Aloes. Although several species are found most of the wild growth consists of A. secondiflora. Aloes are used in medicine as cathartic in form of crude extract or aloins, the authracene glyeorides which are the main active constituent of this plant. However, Kenya aloe fetches very low price in the international market because of poor glyeoside content. The main species of Aloes used commonly and preferred in international market are Cape Aloe (Aloe -ferox) in South Africa and Curcao Aloe (A. barbadensis) from West Indies. It is desirable to introduce superior species in semiarid and arid areas of Kenya. In the meantime samll units should be started in rural areas to make solidified Aloe juice for export. Only small amount of the material is being exported from Kenya.

v) Periwinkle (Cathranthus Roseus): It is a common garden plant which is found growing wild in certain semiarid areas of Kenya mainly in Machakos areas. However, it is not known where the quantity is adequate. In our survey the plant was found to be available only in small scattered patches. Now a careful and detailed survey has to be made to find out whether adequate amount of leaves and roots can be collected at a reasonable price.

The plant which was used in traditional medicine in South Africa and West Indies has recently found its place in modern medicine.

More than 100 alkaloids have been isolated from various parts of the plant out of these only two alkaloids from leaves and one from roots have commercial importance.

The two alkaloids in the leaves are Vinblastin and Vincristine both of which are used in treatment of various forms of cancer. The roots contain an alkaloid Ajmalicine (Raubasine) which is used as a vasodilor. As the quantity of the plant material available as natural growth is too small, the plant has to to be cultivated before any industry for alkaloid production can be started.

In addition to above plant which can be commercialized, there are certain plants which have potential for commercial utilization. However pilot plant study have to be taken up to find out the economies of production of active constituents.

The two most important plants belonging to this category are:-

(a) Rauvolfia mombasiana: The plant is found growing wild in coastal areas. It has been found to contain appreciable amount of Reserpine, a common alkaloid used to reduce blood pressure and as a tranquilizer in certain mental disorders. At present reserpine is isolated from other species of Rauvolfia namely R. serpentina, R. canescens, and R. vomitoria. There is a need to carry out pilot plant study to investigate economics of production of Reserpine from roots of R. mombasiana.

(b) Gloriosa simplex: A common ornamental plant which is also used in traditional system of medicine, R. simplex is widely distributed in Kenya. The tubers as well as seeds of this plant contain a useful alkaloid colchicine. Colchicine is used for treatment of acute cases of gout and arthritis. In form of thiocolchicoside it is also used in treatment of various forms of oedemas. At present colchicine is obtained from corms and seeds

of colchicum autumnale and seed as well as tubers of Gloriosa superba found growing in India and certain countries of Africa.

At present there is acute shortage of colchicine in the world (the present price ranging between K.Shs. 80,000 to 10,000 per kg.) There is a need to carry out a survey of various areas of Kenya to find out the actual content of colchicine in the tubers and seed and carry out pilot plant study to find out the economies of production of colchicine from G. simplex. Initially tubers and seeds can be exported to Italy and West Vermany where colchicine is produced. Later on an attempt can be made to set up an industry in Kenya if the raw material can be made available in large quantities. Ultimately the plant may have to be cultivated.

B/ Aromatic Plants

i) Cedarwood (Juniperus procera): Kenyan cedar (J.procera) is one of the main timber tree grown by forest department. The saw dust which is a byproduct of timber industry contains 2.0 to 3.0% of an essential oil which is referred as East African Cedarwood Oil. As a result of research carried out by Scott Research Laboratory (Now National Agricultural Laboratories) and East African Industrial Research Organisation (now Kenya Industrial and Development Research Institute - KIRDI) Cedarwood oil production was started in Kenya more than 50 years ago and at one time as much as 80 tons of Kenyan cedarwood oil was exported from this country. However, recently the production has fallen and at present only one pencil manufacturing saw mill in Njoro area is producing the oil. Cedarwood is a common essential oil used as a cheap filler and fixative in soap all over the world and there is a considerable market potential. A survey in Njoro area indicated that although there are several sawmills processing cedarwood, only one is producing the essential oil. Most of the saw-dust oil is thus wasted. A particular timber mill which handles only cedarwood is producing approximately 10,000 tons of saw-dust. This would give a minimum of 200 tons of oil (at an average recovery of 2%). The saw-dust can still be used for fuel either as such or in form of briquettes for domestic fuel or production of steam in boilers.

As such there is a need to set up at least 4 to 5 small units each producing 50 tons of oil. Each processing unit can give a gross turnover of 1.5 million shillings.

On enquiry with forest department it was also found that stumps of cedar were not being utilized. Stumps contain more than three times the oil found in saw-dust and it is

a profitable business to distill oil from leftover stumps. The stumps are converted into chips with a mechanical chipper, ground and then distilled in any steam operated strip. There is a need to carry out an investigation regarding production of cedarwood oil from cedar stumps by KIRDI as the material is now wasted.

ii) Geranium (Pelargonium graveolens): Geranium was introduced in Kenya more than 5 years ago. Initially the local geranium called the MAWAH OIL was cultivated. However, since it fetched a very poor price in international market the true geranium strain from Reunion Island was introduced and apprximately 2 to 3 tons of good grade of geranium oil was produced mainly in Naivasha area. However production has been decreasing for the last 3 to 4 years and now there is no production of geranium oil in Kenya. During our survey only one farmer, Mr. R.J. Mennel of Korongo farm in Naivasha area was found to have a few thousand plants in his nursery. One of the main reason for complete stoppage of production by Korongo farm which was the only farm producing geranium for some years is the lack of marketting and very poor price which Mr. Mennel has been getting from his internatior er. The last lot of oil had to be sold for a poor price of K.Shs. 300 per kg. as compared to K.Sh. 800/- for Reunion type of oil in the international market. As a result of our discussion Mr. Mennel was persuaded to take up cultivation again. However, the Government has to do something for organising marketting and also set up at least a dozen cooperative units where geranium oil can be produced. Kenya is one of the few places in the world suitable for production of geranium oil and every effort should be made to produce at least 100 tons of oil annually. If ten small units can be establihsed this would give a gross turnover of at least 50 million shillings (at a minimum prize of K.Sh. 500 per kg, present international price range from 700-800 K.Sh. per kg.) All this aound could be in the form of foreign exchange, as there is a considerable demand in Europe for geranium oil.

iii) Eucalyptus: Kenya has two species of eucalyptus in forest plantations which can be exploited for production of essential oil. There are sizeable pure plantations of Blue Gum Eucalyptus globulus in high altitude areas. Analysis of leaves carried out by Pharmacy department has indicated that oil content is appreciable (to 1.5%). A sample of leaf collected from Nariobi area was analyzed in the chemistry department of Nairobi University and the leaves were found to contain 1% oil. In highlands of Kenya oil content would be still higher. Oil of E. globulus is an important essential oil used in medicine. It contains cineol (euclytol) which i ed in cough lozenges, syrups, inhalers and pain palms and ointments. It is one of the few important essential oils imported in Kenya by various pharmaceutical companies. There is a need to utilize the leaves of E. globulus in Kenya for essential oil production both for internal consumption and export. A detailed report has been prepared by one long-term international expert and a pilot plant was also fabricated. However this pilot plant has not been used. KIRDI should immediately take up a pilot plant study, carry out test marketting and calculate the cost of production for taking up commercial production. The contention of Dr. Davis, the international expert on eucalyptus does not seem to be tenable as there is a considerable market potential for this oil in Eastern Europe and specially U.S.S.R. The market is expected to grow in Asia and Africa with further development of pharmaceutical industry in these countries. It is advisable for forest department in Kenya to include E. globulus in their future programme of planting, so that in addition to wood essential oil can also be produced. This would increase the income of forest department which is only utilizing timber for fuel and pulp.

The other essential oil species which is found in pure stand in the lake areas is Eucalyptus citriodora. The leaves of this species contain 1.5 to 2.0% of an essential oil rich in citronellal, which is used in perfumey and cosmetic industry. The oil has considerable export potential in Europe and U.S.A. Pilot plant studies should also be carried out and sample of oil sent to international perfumery houses which have representatives in Kenya. In future attempts should be made to raise pure plantations in semi arid areas for production of fuel and essential oil.

In addition to the above plants there are some other essential oil bearing plants which have considerable potential use, but pilot scale study is needed by any Research and development organisation to find out the economics of production.

These plants are:-

(a) African citronella (Cymhopogon nardus syn. C. afronardus). Studies carried out by Scott Research Laboratories had indicated that C. nardus grows wild in Rift Valley near Gilgil and Naivasha area which contain 0.5 to 1.0% of an essential oil rich in geraniol and can probably be used either as a substitute of Palmrosa oil (Cymhopogon martinii) or citronella oil (C. winterianus). Detailed pilot plant studies are to be carried out before the oil can be used commercially. If found acceptable to perfumery industry, the grass can be cultivated on the steep slopes to check soil erosion. In addition it would give an additional cash crop. Initially the wild material can itself be distilled for trial marketting.

(b) Mexican Marigold (Tagetes minuta): The plant introduced from South Africa has become the most common weed in all parts of Kenya. During our field survey it was found growing on both sides of roads and fallow land and ranches, in Rift Valley areas, Western Kenya, Highlands and semiarid areas of eastern province as well as in coastal province. Studies carried out by Scott Research Laboratories and again recently by Pharmacy Department of Nairobi University have indicated that flowering tops contain 0.4 to .5% of essential oil. The oil has been in limited use in the perfumery industry in the world and pilot plant investigations have to be carried out in Kenya for its commercial utilization.

(c) Ocimum kilimandscharicum: The plants called "N'kuri" in Kikuyu has been used in traditional system of medicine and is found growing wild in moist places in Nairobi area. Studies carried out by Scott Research Laboratories and recently by Chemistry Department of the Nairobi University have indicated that the leaves contain 0.6 oil with 16 to 25% camphor. At one time the plant was cultivated in Kenya for production of camphor. However, the plantation was given up because of low price of camphor. C. kilimandscharicum has been examined in a number of Asian and African countries for production of natural camphor. As price of both synthetic as well as natural camphor from camphor tree (Cinnamomum camphora) is very low, production from O. Kilimandscharicum has always been found to be uneconomical. However, the plant is growing wild in Kenya can again be examined, as source of camphor by carrying out pilot plant studies and if found economical camphor can at least be produced for internal consumption. Incidently camphor is one of the main plant product imported by various pharmaceutical industries and annual consumption is 2 to 3 tons.

(d) Muhugu Tree (Brachylaena hutchinsii): The wood of this tree which is widely distributed in Kenya yields 0.4 to .6% of essential oil. The oil has vetiver type odour. Further investigation is needed to explore the commercial utilization of oil.

(e) Lemongrass (Cymhopogon citratus): According to Dr. Maitai of Pharmacy Department, West Indian type of lemongrass has become wild in certain areas of Machakos. A survey indicated that the growth of grass is only in scattered areas. Analysis of oil content varies from .2 to 0.5%. Although it does not appear to be economical to exploit the grass from wild sources. But this does give an indication that a good strain of the grass can be cultivated in semiarid areas of Kenya. In order to exploit the grass from wild sources, a survey has to be taken, and at least a few tons of the grass is to be distilled to find out the economics of production.

(f) Micromeria microphylla: It is a small bush growing wild in Limuru, Kinangop and Nyeri district at an altitude of about 6500 ft. The leaves in steam distillation give an essential oil resembling scented yerbena. This oil should be reinvestigated and industrially evaluated.

Para

C/ Pramedicinal Plants

There are a number of plants which are used in medicine or perfumery industry only to a limited scale but these have a large number of other industrial uses. Some of these may not have direct medicinal value but are classified as pharmaceutical aids. The survey indicated that there a number of such plants available in Kenya which have considerable industrial potential.

Some of the most important raw materials which can be immediately commercialized are:-

(i) Papaya (Carica papaya): Kenya is one of the few countries in the world which have ideal agroclimate for cultivation of this plant and in fact Papaya (vernaculer 'Papaw') is one of the commonly cultivated fruit all over Kenya. Papaya is the source of the proteolytic enzyme papain used in medicine. It is used in various digestive enzyme preparation for treatment of dyspepsia and gastric disorders. It is also used in treatment of diptheria for dissolving or softening diptheric membranes, and treatment of infected wounds. The enzyme is often used after surgery to reduce the incidence of blood clot where thromboplasma is undesirable. The enzyme is also used for local treatment of buccal, pharyngeal or laryngeal disorders.

However, only a small portion of Papain is used in medicine and the major portion of this enzyme is used in food and other industries. Papain is the main enzyme used for tenderizing meat and fish. It is also used in beer and other fruit juice industries for removing haze. Papain is also used in production of meat and yeast extracts.

The enzyme is employed as a component of baiting compound in leather industry and for digesting silk in textile industry.

Although there is considerable quantity of papaya available there is only one small unit near Kisumu producing small amount of crude papain in form of dried papaya latex. There is considerable potential for starting at least 10 units in small-scale sector each producing 5 tons of refined papain. This would give an appropriate turnover of 75 million Kenya shillings. Papain has considerable export potential in Europe, U.S.A. and Japan. A detailed prefeasibility study is presented in Annexure (9).

Another proteolytic enzyme which is used along with and also in place of papain, is bromelain which is obtained from pineapple waste as a byproduct of pineapple processing industry. Kenya has considerable potential for putting up at least two units attached to the main pineapple processing factories.

(ii) Gum Arabic (Acacia senegal): Semiarid and arid areas of northeastern Kenya have sizeable natural growth of A. senegal which yields a gum traditionally referred as Gum Arabic in the world trade. Sudan produces more than 80% of this valuable gum. Other producing countries which produce rest of the total supply of the world are Senegal, Mauritania, Mali, Nigeria and Somalia.

Unfortumately, the trees of Acacia yielding gum are not in the control of forest department. It is necessary to bring the main Acacia areas under forest department and start production of gum arabic, under forest control. This would give additional job opportunities to rural people in this area where people have very low income becuase of poor rainfall.

The contention of Dr. Davis that there is no scope for export of Gum Arabic is not correct. The production of Gum Arabic in Sudan is decreasing because of indiscriminate exploitation of trees for fuel while demand of gum arabic is increasing specially because of development of industries in the Third World.

Gum arabic is one of the few gum which is used extensively in pharmaceuticals and food products. The gum is used in tablets as binder and also as coating agent.

In food it is used in fruit gum, chewing gum, liquorice sweets, ceramels and tofees. It is also used in soft drinks as an emulsifier. Because of its water absorbing properties gum arabic is used in bakery products and icecreams. It is also used in brewing industry for stabilizing foam. Other major uses are as adhesive use in lethography and printing industry, ink making, paints varnishes and sizing of paper and textiles. Gum arabic has also found its use as emulsifying agent in cosmetic industry specially in foundation creams, lotions, depillatery creams, anti-perspirants and deodorants.

(iii) Castorseed (Ricinus communis):- Castor grows whild throughout Kenya on both sides of roads and fallow lands. It can also be easily cultivated in poor soils in semiarid and arid areas. A limited amount of seed is collected and exported. The annual export varies from 2000 to 3000 tons. There is sufficient castorseed available in Kenya to justify establishment of medium size castor oil industry.

Although castor oil has now only a limited use in medicine, it has considerable potential for export because of its large number of industrial uses. Castor oil is used in

medicine, cosmetic industry, lubricant industry, paints and varnishes as well as leather industry. Castorcake obtained as a byproduct after removal of oil is used as a very good fertilizer.

(iv) Myrrh (Commiphora sp): A number of species of commiphora exist in Kenya specially in arid and semiarid areas. Gums of these species referred as Myrrh is used in traditional system of medicine and also exported to various countries for a variety of uses which includes its use in flavour and fragrances. A detailed report about Commiphora gums has already been given by an international expert on pharmaceuticals, Dr. Mohamed Tawfik, and it would not be discussed here. However, there is scope for production of essential oils and resinoids of Myrrh for export to Europe.

(v) Neemseed (Melia azedrach): Neem is a introduced tree in Kenya which has become naturalized in the country specially in coastal province where it is a common shade tree on roads and planted as a windbreak on fences in sisal and cashewnut states. It is also the most common shade tree in rural areas on the coast. Various parts of this tree have been used in traditional system of medicine as well as insecticide. The seeds of the tree contains 50 to 60% a fixed oil which can be utilized for nonedible purposes. In India the seed of this tree is utilized for soap making and hundreds of cottage industries have been set up for production of Neemoil for soap making. The cake left after expelling the oil is used as a very efficient fertilizer (7 to 8% nitrogen). The cake when applied to soil as a fertilizer also acts as an effective insecticide against soil borne insects and also controlls plant parasitic nematodes.

A survey and analysis carried out by Dr. Manau of Chemistry Department of Nairobi University has indicated that seeds have appreciable oil content and can be utilized commercially for oil production. It can support at least half a dozen cottage industries in rural areas of coastal province. Collection of seed which is being wasted would provide job opportunities to poor sections of people in the villages.

Pine (Pinus sp.):- Kenya has large plantations of pine. According to the data provided by Forest Departemnt, Kenya has more than 140,000 hectares of pine. The two main species cultivated are Pinus radiata and P. patula. Pine trees are source of rosin and turpentine. Rosin is used in paint and varnish industry and for sizing of paper. Turpentive or oil of turpentine is as such used in medicine, perfumery, paint and varnish industry. Turpentine oil is also an important raw material for a large number of perfumery chemicals and medicinal compounds like camphor, thyamol and menthol.

Kenya is one of the few countries where pine trees are not exploited either for rosin or turpentine production. Both rosin and turpentine are being imported from Europe. During the year 1979 Kenya imported 79.28 tons of turpentine and 818.3 tons of rosin from abroad at a cost of 6.4 million shillings. Both these materials can probably be produced in Kenya at a much cheaper price.

Rosin and turpentine can be produced by two different processes. In countries like Kenya both rosin and turpentine can be prepared by direct tapping of tree and subsequent distillation. It can also be produced as a pyproduct of paper industry from Pan African Paper Mills at Webuye which utilizes only pine as raw material and utilizes kraft process which is ideally suited for production of turpentine and rosin.

According to authorities of Pan African Paper Mills there is no resin in Kenya pine, if their contention is true, it means that Kenya pine has low contant of resin as there is no pine which has no resin. The quantities can be so low that it may not be economical to process. However, tapping experiments carried out by one official of forest department who has got specialization and pine products has indicated that yield of gum resin in P. radiata is appreciable. As such there is a good prospect for taking up a pilot scale investigation for production of rosin and turpentine in Kenya. A detailed prefeasibility study is enclosed in Annexure VI. If the contention of forest official is correct more than 20,000 tons of rosin and turpentine which would go only for export and support a turpentine industry in Kenya.

D/ Requirement of raw materials by indigenous Industries

A survey of the existing pharmaceutical units in the country indicated that requirement of active constituents from plants and crude extract of plants is very small. The approximate requirement of such products is given in Annexure VII. A comparison of the requirement in other countries of the world indicates that both the number of chemicals and the quantities required are very small. Except in limited number of cases the quantities required are so small that there is little scope for setting up of a phytochemical industry for internal use in Kenya unless the Government revises its policy on drugs inthe country. Any industry based on drugs from plants have to be exclusively for export purposes. The reason for this anomaly is the unfortunate condition of the pharmaceutical industry in Kenya. In fact there is very little of manufacturing or formulation in Kenya. Most of the industries except Dawa Pharmaceuticals are in fact packaging industries or sale distribution centres of multinational houses. A few of these units do make some tablets and syrups, but the quantities are so small that in some cases active constituents which are used are less than a few hundred grams. Most of the important drugs from plants are imported in form of finished drugs by multinationals or traders Medicinal practitioners and hospitals are apparently influenced or compelled to prescribe only those drugs which are supplied by the existing pharmaceutical houses and the pharmaceutical houses sell only those drugs which give them very high margin of profits. Use of crude extracts of plants which is so common in all the developed countries like U.S.A., U.S.S.R., Japan and Western Europe is very limited in Kenya as no multinational house would be interested in selling such products, which give them very low margin of profit. Unless the Health Ministry of Kenya changes its

policy at least for few Government owned dispansaries, health centres and hospitals and lays down definite norms for the kind of drugs to be prescribed to general public, there is no scope for large scale use of plant drugs in Kenya. This is possible only when the Government takes a policy decision to manufacture essential drugs in a public sector unit which should be exclusively responsible for supply of essential and life saving drug for majority of the population.

The condition of perfumery and cosmetic industry is no better than the pharmaceutical industries. Most of the high cost perfumes are imported freely in finished forms. These are some soap, household detergent and cosmetic units, but all of them only do mixing of the finished ingredients imported from their principals from abroad at exorbitant cost. All the major multinational houses which have packing units in Kenya do not import any essential oil, but get premixed and coded perfumes from abroad when all of these can be compounded inside the country. There is certain amount of import of perfumery chemicals, but their quantity is so small that no industry can be started for production of such small qualities.

There are a limited number of essential oils resinoids and their derivatives which are imported for use in medicine and perfumery and at least some of these can be produced inside the country. The most important essential oils imported are Aniseed oil, Peppermint oil, Eucalyptus oil and Turpentine oil. The two important derivatives which are imported are Menthol and Camphor. Here again the actual use of such materials can be much larger if finished products are not imported.

There is a good possibility of production of Peppermint oil, Eucalyptus oil and Turpentine and oil. However an industry can be started only if these products are also exported. There is considerable market for all these products in Europe.

One of the main pharmaceutical aid imported in Kenya is Gum Arabic which can be easily produced in Kenya without much effort as the raw material Acacia senegel is available in sizeable quantity in Kenya.

The only other drug which can be obtained from a plant source and which is imported in sizeable quantity is caffeine for pharmaceutical and soft drink industry. Most of this is being used by the Cocacola Bottling company.

More than 90 percent caffeine of the world is obtained from synthetic sources. However, it can be also obtained from tea waste (Commelia sinensis). Natural caffeine is always costlier because of high cost of raw material. However, caffeine is still being produced from tea waste in India. A project for production of caffeine was taken up by Industrial Survey and Promotion Centre but subsequently given up as the cost of tea waste was quoted five to six times than the standard price of tea waste anywhere in the world. Unfortunately the price quotation was obtained from Messrs. Brook Bond Leibig of Kenya who seem to have deliberately quoted a very high price. If the Government of Kenya wants to stop the import of caffeine, export of tea waste has to be stopped. With a considerable fall in the price of tea, it is worthwhile re-examining the caffeine project.

E/ Plants which can be cultivated in Kenya

A study of climatic data of Kenya and actual field survey of different agroclimatic zones in the country indicated that Kenya is ideally suited for cultivation of a large number of both medicinal as well as essential oil bearing plants. Preliminary experiments for introduction of some of the plants were undertaken during the British regime, however, these experiments were not followed up for commercial utilization of the raw material.

On the basis of existing scientific data it can be concluded that following medicinal plants can be taken up for pilot scale cultivation:-

(i) Senna (Cassia sp.): There are two types of Senna in the international market. Indian senna often referred as Tinnevaly Senna (Cassia angustifolia) is the main product in the market and is cultivated in South India. It has a lower glycoside content (2.0 - 2.5%). Alexdrian Senna (C. acutifolia) is found growing wild in Sudan and is referred as Alexandrian because previously it was exported exclusively through the port of Alexandria before the port of Sudan was developed. Alexandrian senna is preferred in international market because of its higher sennoside content (3.5 to 4.0%). Senna glycoside called sennosides are used as lexative all over the world in form of calcium sennoside. While both leaves and pods are used for extraction of sennoside, leaves are also used to a limited extent in form of senna tea in central and western Europe. A portion of the drug is also used in form of crude extract as senna extract.

Preliminary experiment carried out by Bamburi Cement company have indicated that coastal areas of Kenya are suitable for cultivation of senna. The plant can be cultivated even in semiarid areas specially southern lowlands where irrigation facilities are available. It is advisable to cultivate Alexandrian senna in Kenya as it has better market potential and the production of senna has been decreasing in Sudan progressively every year. Initially leaves and pods can be exported and when the production of raw material is sizeable, an industry for production of sennoside can be established in coastal province.

(ii) Periwinkle (Cathranthus roseus): The plant which was used in traditional system of medicine in West Indies and South Africa has been adopted in modern medicine because of its leaf and root alkaloids. As already indicated the plant is found growing wild in certain semiarid areas of Kenya. However, the quantity available is small and it can be cultivated. A detailed prefeasibility study on this plant is attached in Annexure IX.

(iii) Aloe (Aloe sp.: Low rain fall areas, specially those in North Eastern Kenya are quite suitable for cultivation of this plant. As already indicated certain species of Aloe are wild in Kenya. However, these are of inferior quality.Cape Aloe (Aloe ferox) and Curcao Aloe (A. barbadensis) can be introduced and cultivated. These species fetch much better price in international market. A detailed feasibility study has already been made by an earlier expert Mr. N.L. Wake.

There are a number of plants which have never been introduced in Kenya. However climate and soil of Kenya are suitable for their commercial cultivation. These plants have to be first introduced,cultivated on experimental scale, before these can be recommended for commercial cultivation.

The plants which can be tried on experimental scale are:

a) Egyptian Henbane (Hyoscymus muticus):
The plant contains .6 to 1.5 % total alkaloids with more than 85-90% Hyoscymine and 10-25% Hyoscine (scopolamine). It is used as a commercial source of Hyoscymine sulphate and atropine sulphate. Both these alkaloids are extensively used in modern medicine because of their anticholinergic and antispasmodic action in a variety of human ailments. Most of the raw material which is processed in Europe is obtained from wild growth in Egypt. The plant is also cultivated in U.S.A. It has recently been introduced in India in experimental cultivation. All areas of Kenya which have elevation of 4000 ft. and below and which have low rainfall and low humidity are suitable for cultivation of henbane.

b) Dubcisia (Dubosia sp.): There are two species of this tree which is indigenous to Australia. Leaves of (D. myoporcides) contain 2.5 to 3.5% total alkaloid with more than 60% Hyoscine (scopalamine) and it is the main source of Hyoscine in the world totay. Hyoscine, because of its anticholinergic activity is used in motion sickness, and disease of intestine and respiratory tract.

D. leichardtii also contains 2 to 3.5% total alkaloid with more than 60% Hyoscymine and the rest as Hyoscine. It is mostly used as a source of Hyoscymine and Atropine.

All the semiarid areas of Kenya except high mountain ranges and humid areas are suitable for cultivation of this plant. Planting material can be obtained from Australia and India.

c) Ipecac (caphalis ipecacuanha): Ipecac roots contain 2 to 3% total alkaloid most of which is emetine. Emetin is used for treatment of amoebic dysentry. Crude extracts of ipecac is employed as expectorant and emetic Ipecac is cultivated in Malyasia and India. At present there is acute shortage of ipecac roots mainly because of greater use of emetin for treatment of amoemic dysentry as strains of amoebae has developed resistance to synthetic antiamoebic agents.

All the tea growing high altitude areas, like Kericho with high humidity and rainfall are suitable for this crop.

d) Liquorice (Glycyrrhiza glabra): Liquorice is one of the most commonly used medicinal plants. In form of extract and powder it is used in medicine as demulcent, expectorant as well as antiflammatory agent. Its active ingredient is a triterpenoid saponin called Glycyrrhizin. The roots and rhyzomes which constitute the drug contain 5 to 20% Glycyrrhizin. Glycerrhizinic acid is used for treatment of addison's disease, while its derivative Glycyrrhetic acid in form of sodium salt is used as an antiinflammatory agent in treatment of gastric ulcers and skin disorders.

In addition to its use in medicine liquorice has large industrial use as a flavouring and sweetening agent in tobacco, beverages, candies and confectionary. It is also used as a foaming agent in fire extinguishers. All semidry and dry desert areas of Kenya are suitable for cultivation of this drug which has considerable market and export potential. A detailed note regarding cultivation of liquorice is given in Annex. IX.

e) Medicinal Yams (Diosconea sp.):

Certain species of Dioscorea contain a steroidal sapogenine, called diosgenine. Diosgenine, is one of the main starting material for synthesis of sex harmones, corticosteroids, oral contraceptives and anabolic agents. Inspite of development of other sources of steroidal drugs like sterols from soybean oil and total synthesis diosgeninestill continues to be an important source of these drugs. The major diosgenine producers in the world are Mexico, China and India. Most of the raw materials are obtained from wild growth of various sapogenins bearing yams in these countries. However, recent experiments carried out in India have shown that certain Mexican species of Dioscorea can be cultivated as raw material for diosgenine. The two main species which have been found to be amenable to cultivation are Dioscorea floribunda and D. composita. A number of leading steroid manufacturing companies in India have set up commercial farms for cultivation of these yams.

Climatic conditions in Kenya are quire suitable for D. floribunda and D. composita. The entire Rift Valley, specially the lower elevations, coastal province and lake basin areas of Western Kenya are suitable for cultivation of these yams. Planting material can be obtained either from Mexico or India. Once the cultivation is found to be successful, a diosgenine producing industry can be established in Kenya.

f) Belladona (Atropa belladona): Belladona is one of the most commonly used medicinal plant in modern medicine, all over the world. Both the roots and leaves are used. The plant contains .3 to .7% total alkaloid containing Hyoscymine, Hyoscine and Atropine. While first two alkaloids are present in the plant, atropine is formed during extraction of alkaloid from the plants.

Because of its cost, Belladona is not used for production of pure tropane alkaloids, but employed in form of crude, extract, tincture and total alkaloids. On the basis of its anticholinergic and antispasmodic action it is used in intestinal disorders, asthma and to check the spasm in case of urinary bladder pain. It is also used in treatment of peptic ulcers. In form of plaster it is used as an analgesic and antiinflammatory agent for local application. Preliminary investigation carried out by Pharmacy Department of Nairobi University has indicated that the plant can be cultivated in Kenya. However, yield data and information about economics of cultivation are not available as the plant has been cultivated on very small scale. A large scale experiment to calculate the cost of cultivation and profitability has to be carried out. High altitude areas having an altitude of 6500 ft and above are suitable for cultivation of this crop.

g) Ergot of Rye (Clavicaps purpurea):- The trade name ergot is given to the sclerotia of a fungus C. purpurea, which is parasitic on rye. The sclerotia contain more than two dozen alkaloids of which three are widely used in medicine and have considerable demand in world market. Ergometrine is used as an oxitocic agent to facilitate childbirth and to stop postpartum haemorrhage. Ergotamine is used for treatment of migrain and engotoxine group of alkaloids are used as vasodilators to control essential hypertension.

For production of this drug rye has to be introduced in Kenya as a crop and a suitable strain of the fungus has also to be obtained for creating artificial infection of the crop.

All high altitude areas like Molo are suitable for cultivation of this crop.

In addition to above crops which are to be cultivated as cash crops on farms, there are certain trees or shrubs which can be used by forest department in their tree planting programme. Voacanga africana is a tree found growing wild in Tanzania, Zaire and Uganda. Recently the plant has been adopted in modern medicine because of its alkaloids in seed. The seeds of this tree contain 2 to 3% of an alkaloid. Tubersonine which is used as a starting material for synthesis of Vincomine, a common vasodilator used in modern medicine.

Rauvolfia vomitoria is a large shrub found wild in Zaire, Tanzania and Uganda. The roots contain 2 to 3% total alkaloid. The roots and root bark are exported to Europe from Africa for isolation of Reserpine and Ajmaline. Both of these plants can be introduced by forest department in areas adjacent to Tanzania.

In addition to medicinal plants following important aromatic plants can also be cultivated in Kenya. Some of those which have considerable world market and which should be tried are:-

i) Geranium (Pelargonium graveoleus): This plant has already been cultivated in Kenya for at least 50 years and it was introduced in Kenya by Scott Laboratories in early part of 20th Century. However, it has remained confined to one farm in Naivasha area. The plant should be tried in all Rift Valley areas specially those having low to medium rainfall. All areas having elevation of 4500 to 6500 are suitable for this cultivation of this crop.

ii) Lemongrass (Cymbopogon citratus):
Cultivation of West Indian type lemon grass was tried by Scott Laboratories in 1929 at Nairobi. Results were quite encouraging. However commercial cultivation was never tried because of poor price of oil and limited market potential. Grass has now become wild as an escape from cultivation in certain areas of Machakos. All lower wlevation of Rift Valley (6000 ft and below), humid area of Western Kenya, semiarid areas of Eastern province and Coastal areas are suitable for cultivation of this crop.

The leaves give .25 to .5% of an essential oil containing citral. The oil is used to a limited extent for scenting low grade perfumes. However, it is mainly used for isolation of Citral. Citral itself can be used as flavouring chemical or for cheap perfumes used in household cleaners and detergents. Citral can also be converted into ionones and Vitamin A. The grass can be cultivated on poor soil and also used on steep poor slopes to check soil erosion. A detailed note on lemon grass is given in Annexure IX.

iii) Pachouli (Pogostemon pachouli): The leaves of P. pachouli yields an oil called pachouli oil. The oil is used extensively in all high grade perfumes and cosmetic as a fixative and has considerable export potential. The plant was introduced experimentally by Scott Laboratories in 1929 and results were found to be encouraging. However, experiments were discontinued and commercial cultivation was not taken up. Moreover the plant was not tried in ideal climate. Pachouli prefers warm humid climate, and warm humid areas in Western Kenya and the coastal province are more suitable as compared to Rift Valley areas. A detailed note on this crop is given in Annexure IX.

iv) Eucalyptus (Eucalyptus globulus and E. citriodora)

Climate of Kenya is ideally suited for cultivation of both E. globulus and E. citriona. However these should be cultivated as crops for essential oil by farmers in addition to its planting as fuel and timber tree. A detailed report on Eucalyptus has already been made by another expert, Dr. Davis.

In addition to the essential oil crops which have already been tried and found tc grow well, follwoing plants would grow well and should be tried on experimental scale.

1. Citronella (Cymhopogon winterianus):-
War humid areas of Kenya specially those in Western Kenya and Coastal area are suitable for cultivation of Java type citronella. Citronella leaves contain .7 to 1.3% of an essential oil which is used extensively as a raw material for isolation of citronellal, citronellol, geraniol, and a number of other perfumery compounds. The plant should be introduced on experimental scale either from India or Indonesia. A detailed note about citronell is given in Annexure IX.

2. Jasmine (Jasminum grandilorum): Most of the Rift Valley areas and semiarid areas of North Eastern Kenya are suitable for cultivation of Jasmine. Preliminary trials carried out by East African Research Organisation at Thika during the British period showed that Jasmine was found to grow well. Jasmine flowers are used to produce concrete which is extracted by petroleum solvent. Jasmine concrete is one of the most important perfumery raw materials used widely in high grade perfumes and cosmetics. Egypt, Morocco and France are the main jasmine producing areas of the world and there is considerable demand of the commodity in international market. Once cultivation of jasmine is found economical, technology can be transferred either from Egypt, Italy or France through bilateral agreement with perfumery houses. Proper variety of

jasmine can be introduced from Egypt, France or India.

3. Peppermint (Mentha piperita): Peppermint is one of the most important essential oils produced in the world. It is used extensively in medicine and flavouring industry. A limited amount of oil is also imported in Kenya for pharmaceutical purposes. All high altitude Rift Valley areas (600 to 750 ft are suitable for cultivation of this crop. Small scale experiments carried out by Scott Laboratories in 1930s had indicated that the plant can be cultivated in Nairobi area. However, large scale trials have to be carried out to find out the economics of cultivation. Mint can be introduced in Kenya from U.S.A. or India.

4. Japanese mint (Mentha arvensis):- Leaves of Japanese mint yield .4 to .6% of an essential oil containing 70 to 90% of menthol. Japanese mint oil is the main source of natural menthol in the world today. Menthol is an important chemical used in medicine, cosmetic and flavour industry. Although Japanese mint has not been tried in Kenya, warm humid areas in lake basin areas of Western Kenya and the coastal areas are suitable for cultivation of this crop. Both Japanese mint oil and Menthol have considerable export potential. Menthol is also one of the few important chemicals imported for use in Pharmaceutical industry in Kenya.

Lavender (Lavendula sp):- Lavender oil obtained from flowering tops of different species of Lavender can be cultivated on higher altitudes (6500 to 8000 ft). In Kenya Spike lavender was tried in small scale during the British period and was found to give good yield of oil. There is scope to introduce different species of lavender in Kenya.

Lavender oil is one of the most important essential oils used in perfumes, cosmetics and soaps in the world and has considerable export potential and future use in Kenya.

In addition to above mentioned essential oil bearing plants, a number of spice essential oils can also be cultivated in Kenya. These include aniseed oil (Pimpinella anisum), Corinder oil (Coriandrum sativum) Dillseed (Anethum graveolens) oil and carraway oil (Carum caryi).

RESEARCH AND DEVELOPMENT

Research and development on medicinal and aromatic plant in Kenya is in a very preliminary stage. Moreover most of this work is spread over a number of departments consisting of routine survey or academic in nature with no relevance to commercial utilization of these plants in the country. This has happened because of lack of trained personnel, sophisticated scientific equipments and shortage of funds for such research projects.

Inspite of these drawbacks and meagre financial support a group of young men have done useful work in various departments of Nairobi University. This work if followed up and planned properly can lead not only to scientific knowledge, but, definite industrial activity.

The current status of research in various research institutions is described below:

1. Applied Research:- Industrial research which should be aimed at commercial utilization of plants does not exist any where in Kenya. However, such research was started during the British rule as early as in 1929 by scientist of the Scott Laboratories (now National Agricultural Laboratories) and later on by East African Research Organisation (now Kenya Industrial Research and Development Institute - KIRDI). As a result of this work carried out by these institutions, Chinchona and Geranium were taken up on commercial scale, and production of Cedarwood oil was started. A pilot plant for production of crude hecogenine was also established which finally lead to production of this chemical on various sisal growing estates. Unfortunately all work on cultivation and processing of medicinal plant was discontinued

after independence. If Kenya proposes to utilize these plants for industrial purposes a new research organisation as a part of either KIRDI or National Agricultural Laboratories would have to be set up.

2. Survey and Screening: Survey and screening of medicinal plants and plant containing essential oil has been carried out for the last 3 to 4 years in the following departments:-

i) Pharmacy Department, Nairobi University:-
The department has carried out analysis of oil content of a number of essential oil bearing plants which are already growing wild in the country and found that oil content in Eucalyptus citriodora, E. globulus, Tagetes minuta and Lemon grass (Cymbopogon citratus) is appreciable in Kenya. These workers have thus confirmed the earlier work carried out by British workers of Scott Research Laboratories before independence. Scientitist at this department have also carried out introduction and cultivation of certain medicinal and aromatic plants and found that a number of plants like Belladona (Atropa belladona), Digitalis (Digitalis purpurea) and Coriandrum Saativum can be cultivated in Nairobi area. However, yield data and economics of cultivation and nave not been worked out, as the work was carried out on a very small scale.

ii) Department of Chemicstry, Nairobi University:
There are two natural product chemists who have been screening Kenyan plants for presence of essential oils, fixed oils and saponins. Very useful data has been collected regarding new sources of essential oils.

In addition to Ocimum Kilimandscharicum and O. basilicum which were investigated earlier the department has found out two new sources of essential oils which might find industrial use in future. These new sources are Trachonanthus camphoratus, and Sterculia biflora. The department has also carried out screening of wild plants for fixed oils. It has been observed that both Neem (Melia azedrach) and castor seed (Ricinus communis) have high oil contant and can be processed commercially for production of oil.

iii) Department of Biochemistry, Nairobi University: A group of young men lead by Dr. Mugo has been trying to screen plants used in traditional system of medicine in Kenya. Although only a few plants have been screened, Dr. Mugo has carried out extensive survey and has also made careful observation regarding the effect of these plants on patients treated by traditional healers. He has also compiled a list of plants which need investigation as these are used effectively to treat certain diseases.

Certain amount of funds have been made available to Dr. Mugo for taking up the work. However, the amount of funds available, the manpower and scientific personnel available are too small to carry out a meaningful screening programme. The department does not have any natural product chemists and sufficient number of pharmacologists are not available. There is no animal house as such as animals are purchased from outside. However the department is the only place in Kenya where a group of qualified and energetic biochemists are available. Moreover these people are ready to work even under adverse circumstance. The present state of affairs if allowed to continue which actually means sanctioning of small grants by National Council of Science and Technology, would result into only some academic papers.

It is therefore essential that a research centre should be developed at Nairobi University which should be managed by the Department of Chemistry, Biochemistry and Pharmacology. This centre should be equipped and aided by UNIDO in the form of equipment and training facilities to carry out a well planned programme of screening of plants used in traditional system of medicine.

Before taking up such a programme one should keep the basic fact in mind that such a scientific study would not give any immediate result in the form of industrial use of such plants. Somehow an erroneous impression has been created in the mids of officials of Ministry of Health and Industry that research on plants used by witch doctors in Kenya has large industrial potential and infact some people feel that plants used by trational healer can be used immediately to take care of the health needs of people in Kenya. This is a very dangerous proposition and before the Government of Kenya decides to invest any money in such a project, they must understand that although such a research project is very useful and should be given all possible support, it would only create scientific competance in the country and result into generation of useful scientific data. It may also lead to identification of new drugs from plants which may be used in medicine. However, it would take at least 10 years before a new drug can be used in medicine. Any new drug from plants has to go through a long term carefully controlled toxity and clinical trial before it can be recommended for use on humans, as lives of human beings are too precious to be played with by advocating blindly any plant which has some pharmacological activity. It is a misconception to think that all drugs from higher plants which are being used by traditional medical practitioners either in Kenya or other parts of Asis and Africa are safe to be used for general health care. Experiments carried out by Dr. Mugera of

Department of Pathology and Microbiology, in the school of Veterinery Sciences had indicated that some of the most commonly used medicinal plants by certain tribes in Kenya are highly toxic and some of them are highly carcinogenic.

iv) Department of Pathology and Sacterialogy, Faculty of Veterinary Science, Nairobi University:

The department under the guidance of Dr. Mugera has been interested for the past few years in studying the pathological and toxic effects of some of the plants commonly prescribed by tribal healers for treatment of diseases of men and animals. They have found that some of these plants are highly toxic even in low dozes and a large portion of them are carcinogenic. It has also been observed that in these areas and tribes where these plants are used extensively, there is high incidence of cancers both among human beings and domesticated animals. There is urgent need to strengthen this research proejct so that the rural population can be cautioned against use of toxic plants.

If one carefully examines the research work in the four departments at Nairobi University, it becomes apparent that all these departments are working in isolation, which results in duplication of work and the limited amount of funds which are available from the National Council of Science and Technology are not properly utilized. With such isolated projects no department is able to equip itself and the research results remain unutilized. A meaningful programme of researhc which would not only be industrially oriented, but would also generate new scientific knowledge can be only taken up if efforts of all the departments are coordinated under one project.

Priority should be given to those projects which would yield quick results with minimum use of men and materials. There is no need to carry on work on those plants which have been thoroughly investigated in Africa or elsewhere.

Somehow an impression has been created in the official quarters that there is a large potential for production of drugs from indigenous plants used in traditional system of medicine or folk medicine in Kenya. It has been prescribed without looking into already published literature that all of these have to be investigated and screened. In order to probe this question a detailed study of available scientific literature was made and the matter was discussed with scientists who have documented the plants used by traditional healers in the country. It was found that most of the plants used in folk medicine in Kenya are the same as those used in other Asian, African or South American countries. More than 95% of these plants have been thoroughly investigated, their active constituents and pharmacological activity documented. Those which have been found active have also been adopted in modern medicine. All the plants which have been indicated in the chapter II of this report are used in traditional medicine. However, there are 5% of these plants found in Kenya which have not been screened in detail and only these need to be reinvestigated in the research programme to be taken up in future. A research centre with active collaboration of all the departments has to be established to carry out this work. This centre which would carry out preliminary investigation would have to work in collaboration with Medical College and KIRDI, in order to find out the practical and commercial use of any of the plants found to be active and safe to be used in medicine. One basic principle should be kept in mind that the people of Kenya have to be provided their medical facilities based on scientific and modern system of medicine and one cannot think of prescribing crude drugs based on casual observations of witch doctors and pecple practicing folk medicine. Nobody can deny that there may be certain plants used by tribal people in rural areas which can be used as safe and effective therapeutic agent, but these have to go through a series of scientific trials and cleared by the drug control authority of Kenya before these can be used on human being or domestic animals.

RECOMMENDATIONS

1. Utilization of Existing Raw Materials:

All existing raw materials of medicinal aromatic or allied plants, specially those available in sizeable quantities should be processed inside the country. Suggestion for various groups of plants are given below:-

A. Medicinal Plants: Immediate action should be taken for banning the export of Cinchona bark from Kenya and a cinchona alkaloid unit should be set up at Kericho. The parent companies in U.K. and Belgium should be asked to set up the processing factory in collaboration with Kenya Government. If the parent companies do not agree to this proposal, technology can be transferred from India, U.K. or Germany and a public sector unit should be set up to process cinchona bark for production of quinine, quinidine and cinchona febrifuge. This company should also take action for processing of Stramonium (D. stramonium) for production of total extract and Aloe (A. secundiflora) for production of solidified extract.

At least two to three units for production of pure hecogenine from sisal waste should be set up at those states which are growing only A. sisalana for fibre production. Technology as well as machinery for production of crude hecogenine is available with several sisal estates. Technology for production of pure hecogenine can be either transferred through UNIDO from National Research Development Corporation, England or Glaxo Laboratories, the main consumers can be approached to set up a unit in Kenya.

As regards commercial utilization of potential raw materials like periwinkle (C. roseus), Kenyan Rauvolfia (R. mombasiana) and Gloriosa (G. simplex). KIRDI should establish a separate department of natural product Chemistry to carry out necessary research work before these can be used for industrial production. The details of such a set up is given in the section Research and Development.

B. Aromatic Plants: Kenya Government should encourage setting up of more units for production of cedar wood oil from East African cedar saw dust available in Kenya so that at least 200 tons of oil can be produced and exported. Technology for production of the oil is available in Kenya.

Those plants which have to be still investigated and which have industrial potential, should be tried on pilot plant scale by KIRDI after it is able to set up its new division of Natural Products Chemistry. The plants which should be taken up for pilot plant studies are Eucalyptus (E. globulus, and E. citriodora), lemon grass (T. citratus), Mexican marigold (T. minuta), African citronella (C. nardus), Muhugo (B. hutchinsii), Ocimum basilicum (O. kilimandscharicum) and M. microphylla).

C. Paramedicinal Plants: Immediate action should be taken up for putting up a number of unit for production of refined papain. KIRDI has necessary facilities for development of technology as the technology was previously developed by East African Research Organisation, and a demonstration unit has to be established by the institute. It it is not possible for KIRDI, technology can be transferred from Central Food Technological Research Institute in India, through National Research Development Corporation of India. The pine apple processing companies in Kenya should be also advised to produce bromelain from pineapple waste. The technology for production of this enzyme is available in their parent companies. Production of castor oil can be started immediately by contacting any of the companies supplying cold pressing and solvent extraction plant in India or Brazil.

As regards gum arabic, neem oil, oil of the turpentine and resin fro pine, pilot scale studies should be carried out by KIRDI in cooperation with forest department so as to work out the economics. All these commodities can be used in indigenous industries.

2. Introduction of important medicinal and aromatic plants in Kenya:- As already indicated, climate and soil of Kenya is quite congenial for introduction of a number of medicinal and aromatic plants. The list of such plants which can be profitably cultivated in the country has already been given. However, in order to implement this project an applied research and development organisation is needed which does not exist in Kenya. It is suggested that a research group consisting of an agronomist, phytochemist and a chemcial engineer should be immediately created. It is better if this project can be take up in collaboration with National Agricultural Laboratories and KIRDI. The organisation should have at least a 50 acre research farm in Nairobi with substations at various agricultural research station at Thika, Molo, Machakos, Kakamega and the Coast Agricultural Research Station. The existing research station of Agriculture or horticulture department should be used for this purpose. The three scientists appointed for this purpose should be trained for a period of 2 to 3 months at Central Institute of Medicinal and Aromatic plants in India where they will get a chance to study both cultivation,analysis and processing of these plants. After the scientists have been trained the different plants should be introduced on small scale, and those found suitable should be tried on large scale. These scientists would have to develop a package of agronomic practices suited to local conditions. After the plants have been introduced an international expert who is experienced in organising such a research should be provided for 3 months to see that the project is executed properly. UNIDO should finance the training and provide pilot plant equipment for the project. The local cost should be provided by the Ministry of Industry.

3. Research and Development: In order to make use of medicinal and aromatic plant for development of industrial ec-nomy in Kenya, research and development should be organized and strengthened on the following lines:

a) Applied Research: This research should be given top priority as only this type of research activity can lead to development of industries based on medicinal, aromatic and allied plants.

Applied research should be organized at different places.

b) Development of Agrotechnology: This should be organised as already indicated at National Agricultural Laboratory and should initially consist of a senior Agronomist, one Phytochemist and one Chemical Engineer. The centre would be run in collaboration with KIRDI. This group would be responsible for development of indigenous agrotechnology and processing technology for essential oil plants.

c) Development of Processtechnology: This group should be organized at KIRDI and the institure should start a new department of Natural product chemistry. Initially this should consist of one Phytochemist speicalised in chemistry of medicinal plants and an essential oil chemist. The Chemical Engineering Department of the isntitute would collaborate with this group in pilot plant studies. The main work programme of this section would be to develop technology for processing of existing raw materials and carry out pilot scale study of those plants and products whcih are found to be of potential value by the screening group at the University. These scientists would also help in import or transfer of technology like production of hecogenine, cinchona, alkaloids and papain. The two scientists of this group should also be trained by UNIDO in suitable institutions in India or Europe.

d) Survey and Screening of Plants: Survey and screening of indigenous flora shoudl be carried out by a centre to be established at Nairobi University at Chiromo campus. This should be a multidisciplinary group established in collabroation with Chemistry. Biochemistry and and Pharmacology departments of the University. In addition to the existing staff which is involved in such research work,, National Committee on Science and Technology should provide at least two natural product chemists, one pharmacologist and one botanist as necessary supporting staff. The scientists of this group should carry out work on following project:

i) Screening of plants used in traditional medicine. The Biochemistry, Pharmacology and Chemistry Departments would work jointly on this project. The botanist would provide the plant sample and would also carry out ethanobotanical survey in collaboration with Biochemistry department.

ii) Chemical screening of plants for known active constituents of plants and essential oils:
This should be done by chemistry department and pharmacy department should be asked to work in collaboration with chemistry department. Any promising plant once found of potential industrial value should be passed on to KIRDI for pilot plant study, market study and trial marketting.

The coordinator of the project on screening along with one natural product chemist and one pharmacologist should visit Central Drug Research Institute and Central Institute of Medicinal and Aromatic in India to acquaint themselves with latest techniques and methodology of such research work. UNIDO should bear the cost of training of these three scientists for a period of 2 to 3 months. After returning from training these scientists should make a list of scientific equipment needed for chemicaland pharmacological work. UNIDO should provide the necessary

scientific equipment which has to be imported. UNIDO should also provide two jeeps for carrying out survey and collection of plant material and any scientific literature and books required exclusively for this project. National Committee on Science and Technology should finance this project and should not give money for individual projects in this area. This would result into considerable economy.

The project on study of toxity of plants used in traditional system of medicine carried out at Veterinary School under Dr. Megera should be given further support by N.C.S.T. as it is a useful study, so that rural population can be educated not to use these plants which are highly toxic.

After the project at Nairobi University has been started, three international experts with following qualifications should be provided by UNIDO to streamline the research work:

1. One Pharmacologist with long experience of screening of medicinal plants.

2. A natural product Chemist with experience of screening and structure elucidation of active constituents of medicinal plants.

3. One essential oil chemist with experience of screening wild flora for new essential oils.

The proposed research centre should give top priority to the following type of plants:

A. Plants used in traditional medicine: Although all plants should be subjected to general screening, special emphasis should be given on following plants.

1. Plants effective against tropical disease like tropical parasitic diseases including malaria, filaria etc.

2. Plants effective in treatment of tropical intestinal disease like gasteroenteritis, dysentry etc.

3. Anticancer plants.

4. Plants used as antifertility agents.

5. Plants used as anti-inflammatory drugs for treatment of arthritic disease.

6. Plants effective against liver disorder.

B. Screening of plants for known compounds. Special emphasis should be given to plants contrining following types of plants:

1. Plants containing Diosgenins, Solasodine or other steroidal sapogenin.

2. Plants containing tropane alkaloids like Hyoscine and Hyoscymine.

3. Plants containing Colchicine.

4. Plants containing new and novel essential oils.

SUMMARY

A study was undertaken to explore the possibility of utilization of medicinal and aromatic plants in Kenya. Existing raw materials were estimated by discussions with various research organisations and actual field survey of the main areas in Kenya.

Possibility of introduction and cultivation of important medicinal and aromatic plants which have considerable world market was also investigated by studying the various agroclimatic zones of the country. A survey of existing pharmaceutical, perfumery and cosmetic industries was also carried out to assess the requirement of active constituents of plant, crude extracts and essential oils for indigenous use in Kenya. Existing research and development on medicianl and essential oil bearing plants was also studied in order to suggest improvements.

Survey of existing raw materials indicated that Kenya has two main medicinal plants which can be utilized for setting up industries. Cinchona bark which is being exprted can be used for production of Quinine and Quinidine, while sisal juice can be used for production of Hecogenine. Two other medicinal plants which can be commercially utilized are stramonium (Datura stramonium) and Aloe (Aloe secundiflora). They can be used for production of crude extracts.

There are three other plants which need further investigation before these can be used for commercial purpose. These are Rauvolfia mombasiana, Gloriosa simplex and Cathranthus roseus.

The only existing raw material for essential oil is East African cedar (juniperus procera) for production of cedar wood oil. This raw material is being utilized to a limited extent.

In addition there are a number of essential oil plants which have industrial potential, but these need to be investigated on pilot scale before these can be produced commercially. These plants are Eucalyptus globulus, E. citriodora, Cymbopogon citratus, C. nardus, Tagetes minuta, Ocimum Kilimandscharicum, Micromeria microphylla, Brachylaena butchinsii, and Sterculia biflora.

Besides medicinal and aromatic plants, Kenya has raw material for a numebr of other plant raw materials which can be classified as paramedicinal. In addition to their use in medicine the active constituents from these plants have other industrial uses. Such plants include Papaya (Carica papaya) for papain, Pine (Pinus sp.) for rosin and turpentine oil, Acacia (Acacia senegal) for gum arabic, Castor seed (Ricinus communis) for castor oil and Neem seed (Media azedrach) for Neem oil.

A survey of different agroclimatic zones and study of the climatic data indicate that Kenya has ideal soil and climatic conditions for cultivation of a number of medicinal and aromatic plants which can be introduced in the country for expert to developed countries. Those medicinal plants which can be cultivated in the countries are Sapogenin bearing yams (Dioscorea floribunda and D. composita), Belladona (Atropa belladona), ipecac (Cephalis ipecacuanha), Duhoisia sp., Liquorice (Glycyrrhiza glabra), Periwinkle (Cathranthus-roseus), ergot of rye (Claviceps purpurea) and Senna (Cassia acutifolia). The aromatic plants which can be cultivated are lemon grass (Cymbopogon citratus), Java citronella (C. winterianus), Pachouli (Pegostemon-pachouli), Geranium (Pelargonium graveolens), Jasmin (Jasminum grandiflorum), Lavender (Lavendula sp.) and Peppermint (Mentha piperita). Survey of different pharmaceutical, perfumery and cosmetics industries in Kenya indicated that most of the industries are actually nothing but packaging

houses and the medicinal products as well as perfumes are imported as finished products. As such there is only limited scope for indigenous use of medicinal plants or essential oils in Kenya and any industry based on these plants would have to be only for export purposes.

A study of research and development facilities as well as ongoing research projects revealed that research on medicinal and aromatic plants is only in preliminary stages. Facilities for applied research oriented towards commercial utilization of these plants do not exist any where in the country. Most of the research work carried out in the departments of Pharmacy, Chemistry, Biochemistry and Veterinary science at Nairobi University consist of preliminary routine survey and analysis.

It has been recommended that immediate action should be taken for setting up industries for production of cinchona alkaloids from cinchona bark, hecogenine from sisal waste, Papain from Papaya and crude extracts of stramonium and Aloes from D. stramonium and A. secondiflora.

It has also been suggested that a research and development organisation should be created in collaboration with Kenya Industrial Research and Development Institute (KIRDI) and National Agricultural Laboratories for introduction and cultivation of new medicinal and aromatic plants. Detailed otes on cultivation and utilization of important medicinal plants were prepared and have been attached with the report for use by future research personnel.

Recommendation has also been made to establish two research groups for carrying out meaningful and well planned research on medicinal and aromatic plants. It has been suggested that while screening and survey, including pharmacological screening of medicinal plants should be carried out by a multidisciplinary cell to be created at Nairobi University, an applied research group for developing processing technology should be created at KIRDI. The two

groups are supposed to work in close collaboration. It has also been suggested that UNIDO should provide equipment, training facilities and international experts for establishing the two research groups.

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LIST OF ANNEXURES

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REVISED JOB DESCRIPTION OF
DR. AKHTAR HUSAIN
EXPERT ON MEDICINAL PLANTS

As a result of discussion with Mr. Obura, Under-Secretary, Industry, Mr. Mwencha, Dr. Kiruthu and Prof. Bohra it was decided to also include aromatic plants (Essential Oil bearing) as these were related to medicinal plants. It was also decided to revise the job description so as to identify definite industrial projects.

The revised job description would be as follows:-

1) To survey the existing raw material of known medicinal and aromatic plants which are available in the country and others from wild or cultivated sources.

2) To study the approximate requirement of drugs from medicinal plants and essential oils in indigenous pharmaceutical, cosmetic, perfumery or flavour industry.

3) To study the various agroclimate zones in the country so as to find out those with considerable potential market and which can be successfully introduced in the country.

4) To suggest concrete proposals for setting up industries based on either indigenous or introduced medicinal plants including training of personnel for cultivation processing of such plants.

5) To make a survey of existing infrastructure of Research and development, existing status of research projects in different research institutions of the country and suggest future programme of research for utilization of indigenous medicinal and aromatic plants which

have not been investigated in detail. Special emphasis would be laid on indigenous flora containing essential oils and those plants which are used extensively in traditional system of medicine so as to suggest industrial uses for these plants in future.

Annexure II

WORK PROGRAMME OF DR. A. HUSAIN, EXPERT ON MEDICINAL PLANTS

1. Arrival in Nairobi 1.4.81
2. Discussion with Mr. Mwencha, Chief, Industrial Promotion Department and Under-Secretary Industry, Mr. Obura 2.4.81 to 4.4.81.
3. Visit to various scientific institutions and organisations 5.4.81 to 14.5.81.
4. Survey of existing pharmaceutical, perfumery and cosmetic industries in Kenya 15.5.81 to 31.5.81.
5. Field Survey of different Agricultural areas of Kenya 1.6.81 to 14.6.81.
6. Prefeasibility study and preparation of detailed notes on medicinal and aromatic plants 15.6.81 to 30.6.81.
7. Writing of terminal report 1.7.81 to 28.1.81
8. Departure from Nairobi 29.7.81

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Annexure III

LIST OF PEOPLE AND ORGANISATIONS CONTACTED

1. Prof. C.K. Maitai and Prof. Talalaj, Department of Pharmacy, Nairobi University.

2. Prof. Megera, Faculty of Veterinary Sciences, Nairobi University.

3. Dr. R.M. Munavu and Dr. A.N. Mengech of Chemistry Department, Nairobi University.

4. Mr. S.A. Nganga and Mr. P.G. Otieno of National Agricultural Laboratory, Nairobi.

5. Dr. Frederick Owino, Forestry Department, Nairobi University.

6. Mr. S.K. Njuguna, Director, National Horticultural Research Station, Thika.

7. Mr. J.W. Carpenito, Plant Quarantine Station, Muguga.

8. Dr. N. Mugo, Department of Biochemistry, Nairobi University.

9. Mrs. Christine Kabuye, East African Herbarium.

10. Dr. Miss B. Hagos, Chief Quality Control Division, Dawa Pharmaceuticals.

11. Dr. A.D. Tumboh - Oeri Department of Biochemistry, Nairobi University.

12. Dr. J. Mugo, Dept. of Biochemistry, Nairobi University.

13. Dr. J. Miguda-Alila, Science Secretary, National Council of Science and Technology.

14. Dr. R.O. Arunga, Director, Kenya Industrial Research and Development Institute.

15. Dr. P.N.K. Nair, Senior Research Scientist, International Council of Research on Agro-forestry, Nairobi.

16. Dr. P. Huxley, Economic Botanists, International Council of Research on Agro-forestry.

17. Dr. Gacii, Secretary, National Council of Science and Technology.

18. Mr. G.D. Oyango, Deputy Chief Conservator of Forests (Utilization), Nairobi.

19. Mr. Francis Nganga, Forest Utilization Officer, Department of Forests, Nairobi.

20. Mr. Titus Njagi, Forest Utilization Officer, Forest Department, Karura.

21. Dr. J.L. Odera, Conservator, Research Dept. of Forests, Muguga.

22. Dr. B.H. Waite, Kenya Agri Research Institute.

23. Prof. Kokwaro - Department of Botany, Nairobi University.

24. J.J. Ondieki, Chief Research Officer, Ministry of Agriculture.

25. Mr. J. Adala, Senior Research Officer, Ministry of Agriculture.

26. Pfizer Laboratories, Nairobi.

27. Nicholas Laboratories, Nairobi.

28. Glaxo Laboratories, Nairobi.

29. Pharmaceutical Manufacturers, Nairobi.

30. Boots Company Kenya, Nairobi.

31. East African Industries, Nairobi.

32. Manhar Brothers, Nairobi.

33. Cheesborough Ponds, Kenya Nairobi.

34. International Flavours & Fragrance, Nairobi.

35. Colgate Palmolike Ltd., Nairobi.

36. Reckitt & Colman Nairobi.

37. Vicks Products Ltd., Nairobi.

38. Korongo Farm, Naivasha.

39. Pyrethrum Board of Kenya, Nakuru

40. Pyrethrum and Horticultural Research Station, Molo

41. Gambogi Papaw Factory, Kisumu

42. Panafrican Paper Mills, Webuye.

43. National Agricultural Research Station, Kitale

44. Taita Sisal Estate, Taita Hills

45. Brooke Bond & Leibig, Kericho
46. Coast Agricultural Research Station
47. Vipingo Sisal Estate, Malindi.
48. Dry Farming Research Station, Machakos.

Annexure IV

LIST OF IMPORTANT ACTIVE CONSTITUENTS OF PLANTS USED IN MEDICINE

S.N.	Active Constituents	Plant Source	Pharmacological activity
1.	Steroidal Drugs obtained from steroidal spogenine	Dioscorea sp.	antiinflammatory, anti-arthritic harmonal
2.	Opium alkaloids (Codiene, morphine papaverine)	Papaver somniferum	alalgesic antitussive smooth muscle relaxant
3.	Tropane alkaloids (Hyoscymine, Atropine) Scopolamine	Hyoscymus muticus Duboisia sp., Datura sp.	Parasympatholytic
4.	Roserpine	Rouvdfia Serpentina, R. vomitoria R. canascens	Hypotensive Psychotropic
5.	Quinine Quinidine	Cinchona sp. "	antimalarial antiarrythmic
6.	Digital glycosides (Digoxine lanatosides)	Digitalis lanata	cardiatonic
7.	Cocanine	Erythroxylon coca	anaesthetic
8.	Cemetine	Cephalis ipecacuanha C. acuminata	antiamoebic
9.	Ergot Alkaloids Ergometire Ergotamine Ergotoxine	Claviceps purpurea	Oxitocic Vasoconstrictor Vasodilator
10.	Pilocarpine	Pilocarpus jaborandi	Parasympathomimetic
11.	Senna Glycoside (Sennoside)	Cassia angustifolia C. acutifolia	Laxative
12.	Psyllium mucilage	Plantago-ovata	Laxative
13.	Cathranthus alkaloids Vincristin, Vinblastin Ajmalicine	Cathrantus roseus	anticancer vasodilator
14.	Colchicine	Colchicum sp. Gloriosa superba	anti-inflammatory
15.	Glycyrrhetic acid	Glycyrrhiza glabra	anti-inflammatory

Annexure V

LIST OF IMPORTANT CRUDE EXTRACTS PLANT USED IN MEDICINE

1.	Belladona	(Atropa belladona)
2.	Ipecac	(Caphalis ipecacuanha)
3.	Opium	(Papaver somniferum)
4.	Henbane	(Hyoscymus niger)
5.	Stramonium	(Datura stramonium)
6.	Cescara sagrada	(Rhamus purshiana)
7.	Liquorice	(Glycyrrhiza glabra)
8.	Rhuharb	(Rheumofficinale) R. palmatum
9.	Valerian	(Valeriana walichii)
10.	Podophyllum	(Podophyllum peltatum) P. emodi
11.	Capsicum oleoresin	(Capsicum annum)
12.	Digitalis	(Digitalis purpurea)

Annexure VI

LIST OF IMPORTANT ESSENTIAL OILS USED IN MEDICINE, PERFUMERY AND FLAVOUR INDUSTRY

1.	Oil of Turpentine	(Pinus sp.)
2.	Peppermint oil	(Mentha piperita)
3.	Japanese mint oil (source of Menthol)	(Mentha arvensis)
4.	Spearmint oil	(Mentha spicata)
5.	Lemon grass oil	(Cymbopagon citratus) (C. flexuosus)
6.	Citronella oil Java	(Cymbopogon winterianus)
7.	Palmrosa Oil	(Cymbopogon martinii)
8.	Sandalwood oil	(Santalum album)
9.	Geranium oil	(Pelargonium graveolens)
10.	Pachouli oil	(Pogostemon pachouli)
11.	Lavender oil	(Lavendula s: ,
12.	Clarysageoil	(Salvia scalaria)
13.	Vetiver oil	(Vetiveria zizinoides)
14.	Rose oil	(Rosa damascena)
15.	Jasmine concrete	(Jasminum grandiflorum)
16.	Eucalyptus oil	(Eucalyptus sp.)
17.	Coriander oil	(Coriandrum sativum)
18.	Dill seed oil	(Anethum graveolens)
19.	Celery seed oil	(Apium graveolens)
20.	Aniseed oil	(Pimpinella anisum)
21.	Clove oil	(Eugenia caryophyllus)
22.	Cinnamon leaf and bark oil	(Cinnamomum zeylanicum)

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Annexure VII

ESTIMATED REQUIREMENT OF CRUDE EXTRACT OF MEDICINAL PLANTS AND THEIR ACTIVE CONSTITUENTS IN KENYA*

I.	Name of the Commodity	Approx. quantity in kg.
1.	Caffeine	10,000
2.	Atropine sulphate	0.1
3.	Hyoscymine sulphate	0.1
4.	Scopolamine Hydrobromide	0.1
5.	Capsicum oleoresin	2,000
6.	Ext. glycyrrhiza	5000
7.	Glycyrrhiza powders	2500
8.	Ipecac extract	200
9.	Hyoscymus extract	100
10.	Tincture Belladona	500
11.	Scilla extract	100
12.	Stromonium extract	50
13.	Valerian extract	50
14.	Extract ergot	50
15.	Gum Arabic	12000
16.	Papain	500

*Estimates are based on survey of important Pharmaceutical Industries in Kenya.

Annexure VIII

ESTIMATED ANNUAL REQUIREMENT OF ESSENTIAL OILS AND THEIR DERIVATIVES IN KENYA*

Name of Commodity		Requirement in tons
1.	Oil of Turpentine	76.2
2.	Peppermint oil	1.0
3.	Eucalyptus oil	1.0
4.	Aniseed oil	0.5
5.	Menthol	2.0
6.	Thymol	0.5
7.	Camphor	3.0
8.	Citronellal	1.5
9.	Geraniol	0.5
10.	Linalol	0.6
11.	Linalyl acetate	0.5
12.	Methylionone	1.5

*Estimates are based on survey of important perfumery and cosmetic Industries in Kenya.

Annexure IX

FEASIBILITY OF PRODUCTION OF SOME IMPORTANT MEDICINAL AND AROMATIC PLANTS AND THEIR DERIVATIVES IN KENYA

PRODUCTION OF CINCHONA ALKALOIDS IN KENYA

Botany and Geographical Distribution:

Cinchona alkaloids are some of the most important plant products used in medicine throughout the worls. The alkaloids are obtained from the bark of the Cinchona tree (Cinchona sp.). There are more than 65 species of Cinchona of which the following species are the most commonly cultivated for alkaloids:

1. Cinchona calisaya (yellow bark)
2. C. ledgeriana (ledger bark)
3. C. officinalis (pale bark)
4. C. succirubra (Red bark)

Hybrids between C. succirubra and c. ledgeriana are also cultivated. The main cinchona producing countries are, Indonesia and Zaire. Other countries where cinchona is cultivated are Tanzania, Rwanda, Kenya, Sri Lanka, India, Bolivia, Colombia, Costa Rica, Equador and Guatemala.

Constituents and uses:

Cinchona contains more than 20 alkaloids of which quinine and quinidine are the most important. Other important alkaloids are cinchonine and cinchonidine. The total alkaloid content varies from 3 to 16% with an average of 6 to 7%. Quinine in form of sulphate or hydrochloride is used as an anti-malarial. Although a number of synthetic substitutes are available it is still a drug of choice for treating acute cases of malaria. Quinidine is used as a cardiac depressent (anti-arrhythmic agent).

Quinine hydrochloride is extensively used as a flavouring agent in soft drink industry in U.S.A. and U.K. A small portion of the bark of cinchona is also used in extracts and tintures as tonic and febrifuge.

World Production and Trade

The total annual production of cinchone bark is approximately 4,000 to 10,000 tons. The main importers of cinchona bark are West Germany (471 ton) U.K. (795 tons), France 590 tons), Belgium, Netherlands and Italy are other major importers. These figures are based on Unctad/Gatt data in 1971. At present the situation has changed considerably. The two major bark exporting countries, namely Indonesia and Zaire have started production of alkaloid inside the countries. The present total production of cinchona alkaloids is 500 to 600 tons. According to 1972 figure the production in different countries was as follows:

Netherland	310 tons
West Germany	90 tons
U.K.	70 tons
France	30 tons
India	30 tons
Italy	20 tons

Now the situation is quite different today both Indonesia and Zaire have forced the parent manufacturing companies in Netherlands and West Germany to start manufacture of cinchona alkaloids in their respective countries.

The major consumers of the alkaloids are U.K., U.S.A., West Germany, France, Italy and Japan. A considerable portion of the alkaloids are used inside the producing countries like India and Indonesia.

The growth of market of alkaloids has ranged between 2-5% with very little increase in production of bark in the producing countries. Because of recurrence of Malaria in Asia and Africa and development of resistance in the strains of malarial parasite, the use of cinchona alkaloids is going to grow. However, the growing importance of cinchona alkaloids in the developed countries is because of use of quinidine as a heart drug

and use of quinine as a flavour in tonics and soft drinks which is bound to grow. As such there is considerable scope for production of cinchona alkaloids.

Prospects for production of cinchona alkaloids in Kenya: Kenya is one of the main cinchona bark producing countries of Africa. Kenya has been exporting 500 to 600 tons of cinchona bark to U.K. and Belgium. Unfortunately, this is the only country in the world which is exporting the crude raw material of an important medicinal plant. Immediate action should be taken to stop the export of the crude material and the importing company in U.K. should be asked to set up a processing unit in Kenya. If the company fails to do so, technology should be transferred from India through UNIDO. The amount of raw material is sufficient to produce 25 tons of alkaloid (at an average recovery of 5%) which would give an annual turnover of more than 30 million Kenya Shillings annually resulting into increase in foreign exchange earnings and provide job opportunities to Kenyan citizen.

At present the entire cinchona plantation is confined to one estate owned by Messrs. Brooke Bond Leibig The Government should start cinchona plantation on co-operative farms.

PROCESS FOR PRODUCTION OF CINCHONA ALKALOID

For the purpose, finely powdered bark is mixed with about one third of its weight of sifted slacked lime and 5% aqueous solution of caustic soda. The mixture is extracted under stirring, in steam-jacketed vessel with high boiling kerosene. Three successive extraction are made. The mixed extracts are shaken with sufficient hot dilute sulphuric acid to convert the alkaloids into sulphates. The oil is separated while hot and neutral aqueous solution cooled when quinine sulphate separates out and is subsequently purified by recrystallization from aqueous solution after decolorizing with animal charcoal. The other alkaloids are precipitated by adding alkali to mother liquor and individual alkaloids separated by selective solvent extraction.

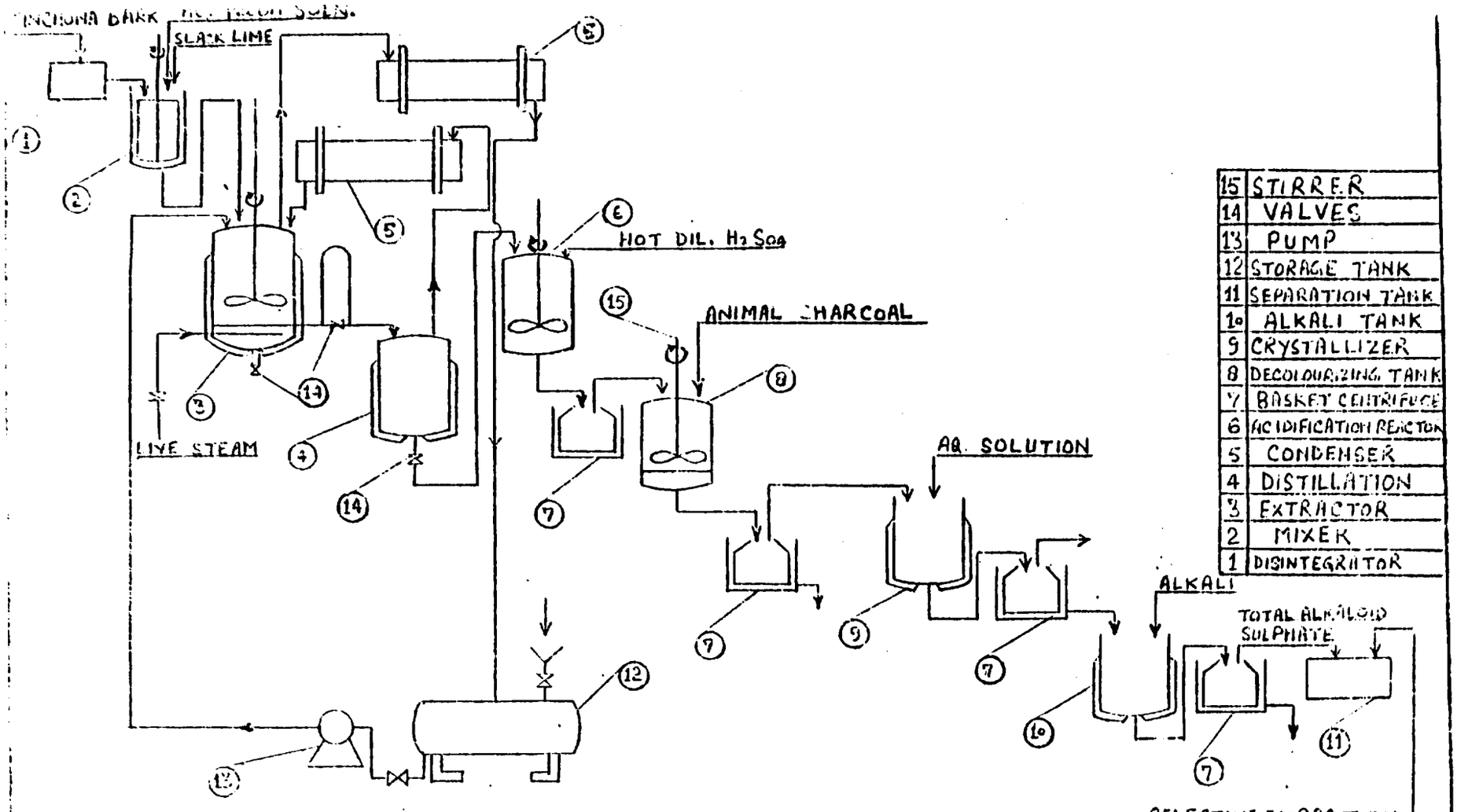
CHEMICALS

For the extraction of quinine, 2000 kg. bark per day at Mugpoo the chemicals used are:

Lime:	200 kg.
Caustic Soda:	150 kg.
Water:	3,000 gallons
Oil:	5,000 gallons

LIST OF EQUIPMENT

1) Disintegrator
2) Mixer
3) Extractor
4) Distillation Uni
5) Condenser
6) Acidification Reactor
7) Basket Centrifuge
8) Decolourizing Tank
9) Crystallizer
10) Alkali Tank
11) Separation Tank
12) Storage Tank
13) Pump
14) Valves
15) Stirrer



FLOW DIAGRAM FOR PROCESSING OF CINCHONA BARK

PROSPECTS FOR PRODUCTION OF PAPAIN IN KENYA

Introduction:

Papain is a proteolytic enzyme obtained from fruits of papaya (PAPAW) (Carica papaya L.). Papaya is a common table fruit cultivated extensively in all tropical areas. Some of the major countries producing papaya are Sri Lanka, India, Thailand, Phillipines, Malyasia, Zaire, Tanzania, Uganda, Kenya, West Indies and Cuba. Out of these, papain is produced in Sri Lanka, India, Phillipine and African countries of Zaire, Tanzania, Uganda and Kenya.

Uses of Papain:

Papain is one of the most important proteolytic enzymes used in medicine. It is used extensively in digestive enzyme preparations employed in treatment of Dyspepsia and gastric disorders.

The enzyme is also used for treatment of Diptheria for dissolving diptheric membranes and treatment of infected wounds. It is used after surgery to reduce the incidence of blood clots where thromboplasma is undesirable. It is also employed in local treatment of buccal, pharyngeal and laryngeal disorders.

Only small portion of papain produced in the world is used for pharmacuetical purposes. Most of the papain is used in food industry.

One of the main use of papain is its use as a meat and fish tenderizer. As a meat tenderizer the enzyme is used in two different ways.

A common method employed in U.S.A. is to inject beef animals with papain before slaughtering. This is called the Poten process and used to a large extent in that country.

In most of other countries of the world it is used as a constituent of meat tenderizing salts used before cooking. Papain is also used in production of fish meal.

A considerable portion of the enzyme is used in the brewery industry for removing haze from beer. It is also used in other beverages specially fruit drinks to produce clarified juices.

Papain is also used in making yeast and meat extract.

In leather industry papain is used as a component of baiting compound. In textile industry papain is used in enzymic digestion of silk. It is also used in laundry in dry cleaning and as a constituent of washing detergents.

World Production and Trade:

Exact data from all producing countries is not available. However, according to International Traee Centre (UNTAD, Gatt.). In 1972 the total production was approximately 400-500 tons per year. The major producing countries are Zaire (136-195 tons) Uganda (175 tons). Tanzania (14-15 tons) Kenya (3-4 tons), Sri lanka (24-25 tons) and India (40-50 tons). Except in the case of Zaire and India where refined papain is produced, other countries export crude papain which is nothing but dried latex of papaya fruit. The crude papain is exported to U.S.A. and European countries where it is refined. Kenya also export dried papaya latex to a limited extent (2 to 3 tons).

World Trade and Future Prospects:

The total world demand (based on estimate in 1974) is approximately 400-500 tons. The major importing countries are U.S.A. (72 to 150 tons). Japan (39-85 tons) U.K. (16-23 tons) Japan (6 tons). This date does not include consumption in communist countries of Eastern

Europe and China which have sizable demand. The demand of the product is bound to grow with further improvement in the standard of living in the 3rd world where meat and fish industry is still in the developing phase. As such there is considerable prospect of production of refined papain in the countries of Asia and Africa.

Prospect for production of Papain in Kenya:

Kenya with its mild climate is an ideal place for production of papaya as well as papain and Equatorial Africa is the best place for production of this enzyme. Coastal areas, the Rift valley and warm humid areas of Western Kenya have got optimum conditions for setting up of at least half a dozen units (small scale sectors) producing approximately 10 tons of papain. Each unit would have a turnover of approximately 2 million Kenya Shillings. Papaya should be grown on small farmer's field and the processing unit should buy crude latex from the farmers.

As regards the technology of production of papain, it is so simple that scientist of KIRDI which has got a fairly equipped food technology laboratory can develop it and pass on to small producers. In case the scientists of KIRDI can not do it, the scientists of KIRDI should be trained by UNIDO at Central Food Technological Institute in India. Alternatively, the Institute can be asked to transfer technology through UNIDO.

The only other substitute of Papain is the enzyme Bromelain which is used along with or in place of Papain. Bromelain is obtained as a by-product of Pineapple processing industry. KIRDI should advise the pineapple processing units in Kenya to recover this enzyme from pineapple waste.

PROSPECTS FOR PRODUCTION OF TURPENTINE IN KENYA

Botany and Geographical Distribution:

Oil of Turpentine is obtained from wood of various species of Pinus (Family, Pinaceae). The most common species of Pinus which are exploited for production of Gum rosin and Turpentine are as follows:

1. Pinus Caribea Mor
2. P. echinata Mill
3. P. halpensis Mill
4. P. Khasya Royle
5. P. leiophylla Schlect & Cham.
6. P. merkussi Jun & de Vries
7. P. nigra Arn.
8. P. plustris Mill
9. P. patula Schlect & Clram
10. P. pinaster Ait.
11. P. pinea L
12. P. ponderosa Doug.
13. P. pseudostrobus & indl.
14. P. radiata D. Don
15. P. roxburghi Sarg.
16. P. Longifolia Roxb.
17. P. sylvestris L.
18. P. wallichiana A.B. Jack

Although oil of turpentine is produced in all the countries of the world wherever pine trees are grown, the most important turpentine producing countries are U.S.A., U.S.S.R., China, Australia, India, Japan, Finland, Sweden, New Zealand, Greece, South Africa, Pakistan, Mauritiaus and South Africa.

Production Methods:

Turpentine can be recovered from pine trees by two different methods:

(1) Direct Tapping: In countries where labour is cheap, Gum Resin is obtained by injuring the trees and collecting the gum which exudes out from the tree trunk. The gum resin thus obtained contains 80% rosin 20% turpentine oil which is separated by simple steam distillation.

(2) By product of pulping industry: In a number of developing countries where extensive and manual tapping is costly, turpentine is recovered as a by product of paper and pulp industry in form of crude sulphate turpentine when the wood is digested either by the sulphite process or the kraft process. United States alone produces more than 150,000 tons of turpentine by this process.

A limited amount of wood turpentine is also obtained from distillation of pine stumps.

Constituents and Uses:

Rosin is used in paint and varnish industry and in signing of paper.

Oil of Turpentine contains a large number of terpenes which differ from species to species. However, the major constituent of the oil are α-Pinene, β-pinene, Δ-3-Carene and longifoline.

A limited amount of turpentine oil is used directly in paints, varnishes and medicine. After processing pine oil can be produced which is used in perfumery and cosmetic.

However the major use of turpentine is the basic raw material for synthesin of a large number of chemicals used in perfumery cosmetic, medicine and flavour

industry. The terpenes which are obtained from Turpentine are α and β pinenes. Both serve as the main raw materials for synthesis of Menthol, Thymol, Camphor, Citral, Citronellal, Hydroxy citronellal, Geraniol, Genanyl Acetates Linalol, Linalyl Acetate. Menthol and Thymol and Camphor are some of the most important chemicals used in medicine, flavour and perfumery. Other terpenes are used in perfumery and cosmetic industry. Other terpenes of perfumery value obtained from turpentine are, Carenes, Longifoline, Turpeniol, Terpene Hydrate and a large number of less important terpene compounds. Derivatives of turpentine have also been used for synthesis of synthetic pyrethroids which are used as insectisides as a substitute for natural pyrethrines.

Prospects for Production of Turpentine in Kenya:

According to authorities of forest department, Kenya has approximately 140,000 hectare of pine plantation and this area is expected to grow in future. The two main species grown in the country are Pinus radiata P. patula. Initial studies on tapping of Paradiata were carried out by Mr. Titus Njagi, a forest officer in 1974. According to his observation results regarding yield of gumresin were very encouraging. However, the project was given up as Mr. Njagi was transferred to another project. Incidentally during his training in Czechoslovakia Mr. Njagi has specialized on production of turpentine from pinewood.

In order to explore the possibility of putting up an industry based on turpentine oil there is a need to take up a pilot scale study by Kenya Industrial Research and Development Research Institute in cooperation with research division of forest department at Muguga. KIRDI should produce at lease a few hundred kgms. of turpentine oil, get it evaluated by pharmaceutical houses and paint Industry and put up a project if the process is found to be economical.

The Pan African Paper Mill should be asked to take up a project for recovering turpentine as a by-product which is apparantly being wasted Most of the turpentine produced would be ultimately used in Kenya in paint, varnish and pharmaceutical industry. At present Kenya is importing 76.0 tons of Turpentine, 818 tons of rosin at a cost of KShs.6.15 million which can be easily produced inside the country. If the quantity produced is large, it can be exported as there is ready market for Turpentine product in Europe. Once it is established that a sizable production of turpentine is possible, Kenya can think of setting up of a turpentine based industry for production of fine chemicals like menthol, camphor or perfumery compounds. In that case the services of an expert who is specialized in turpene technology can be obtained. Alternatively, direct contact can be established with any of the number of multinationals who would be happy to set up joint venture in collaboration with Kenya government. However, the technology of production of turpentine oil is so simple that KIRDI would be able to set up a plant in collaboration with Forest Department.

If the estimates of Mr. Jagii are correct one hectare of pine plantation would easily give at least a ton of gum resin and even if 20,000 hectare are tapped annually 20,000 tons of gum resin would be obtained. This would give 4,000 tons of turpentine oil and 16,000 tons of rosin. At a rate of a minimum of KShs.10,000 per ton of turpentine and KShs.200/-ton of resin, it would mean an annual turnover of KShs.40 million. However these are purely theoretical figures. Actual cost of production and feasibility of project can be only worked out when a pilot plant study is carried out by KIRDI.

IPECAC, A CROP FOR HUMID AREAS IN RIFT VALLEY IN KENYA

Botany and Geographical distribution:

There are two types of Ipecac in the world market:

(1) Cephalis Ipecacuanha (Rio or Brazillian Ipecac)
(2) C. Acuminata (Cartegena, Nicaragua or Panama Ipecac)

The main Ipecac producing countries in the world are Brazil, India, and Malaysia, which produce Brazillian Ipecac and Costa Rica, Nicaragua, Colombia and Panama which produce Panama Ipecac. The total world production is 80-90 tons and the production has been falling progressively.

Soil and Climate:

Ipecac requires wild humid climate. It re uires soils which are rich, deep and with high organic matter. All high altitude areas in Kenya like Kericho which have high rainfall and where tea is cultivated are suitable for Ipecac.

Method of Cultivation:

Ipecac is propagated from seeds. Seeds are planted on raised beds. A mixture of farm yard manure and humus is mixed in the top 6" of the beds. The beds are provided with shade with bamboo strips. After the seedlings are six months old these are transferred to production beds which are also shaded with permanent bamboo or thatched roofs. Heavy doze of farmyard manure and leaf compost is applied before seedlings are planted in the beds at a distance of 9". The beds should be irrigated frequently with a sprinkler. The crop is ready to be harvested after 2 years of growth, when the roots are dug, washed and dried.

Active Constituents and Uses:

Ipecac roots contain 2 to 2.5% total alkaloid. The main alkaloid which is used commercially is emetine. Other major alkaloids present in roots are cephaline and psychotrine.

Emetine is used for treatment of amoebic dysentry while crude extract of roots is used as an expectorant and emetic.

World Market and Future Prospects

The main importing countries of Ipecac root are Federal Republic of Germany, France, United Kingdom, U.S.A. and Japan. In addition Ipecac extract is used in all countries of Asis, Africa and Europe. An present, the demand is several times than supply and the production of drugs is limited. Any country which can produce Ipecac roots would find ready market in Europe. The demand of emetine and Ipecac has increased recently as amoebae have developed resistance to synthetic antiamoebic drugs.

Programme for Production of Ipecac in Kenya

The seeds should be obtained from India, Malaysia or Brazil. These should be tried in Kericho area. As it is a highly specialized crop only tea planters can take up its cultivation.

Economics of Cultivation

1.	Preparation of Nursery	KShs.1,000
2.	Preparation of seed bed with shade	500
3.	Cost of fertiliser and manure	1,000
4.	Irrigation	500
5.	Interculture	500
6.	Harvesting and drying	2,000
7.	Rent on land	200
8.	Total operating cost for two years	10,200
9.	Interest at 10%	1,000
	Total cost per hectare for two years	11,200

Gross return per hectare at the rate of KShs.100.00 per kg. of root and average yield of 500 kg. roots per hectare = 500 x 100 = 500,000

Net profit per hectare per year $\frac{500,000 - 11,000}{2}$

= KShs.19,500 per ha per year.

LIQUORICE, A POTENTIAL CROP FOR ARID AREAS OF KENYA

Botany and Geographical Distribution:

There are four types of liquorice available in the world market. These are as follows:

1. Glycyrrhiza glabra var typica (spanish liquorice)
2. G. glabra var glandulifera (Russian liquorice)
3. G. glabra var heta-violacea (Persian liquorice)
4. G. uralensis (Chinese liquorice)

Most of the liquorice is found growing wild and at present it is produced in Spain, France, Italy, Greece, Iran, Syria, Iraq, Turkey, Lebanon, Afghanistan, U.S.S.R. and China. Most of the requirement of the world comes from Iraq, Iran, Syria, China and U.S.S.R.

Soil and Climate:

Liquorice grows best in light sandy soils in areas where rainfall is less than 300 mm. Heavy soils or areas where humidity is high are unsuitable for cultivation of this plant. Dry areas in North eastern Kenya are suitable for cultivation of this crop.

Method of Cultivation:

Liquorice is propagated by rhizome cuttings. In Kenya cuttings approximately 9 to 12" long should be planted in rows approximately 70 cm apart. The plant to plant distance should be kept as 60-70 cm. The cutting should be planted during the long rains either in March or April. The crop does not require any special care such as weeding or fertilizer application. The crop is ready for harvest after two to three years when the roots and rhzomes are dug, washed, dried and packed. One hectare of crop gives approximately 1000 to 1500 kg. of dried roots.

Active Constituents and Uses:

Liquorice roots contain 5 to 20% of a triterpenoid saponin called glycyrrhizin which is 60 times more sweet than cane sugar.

In addition to wide use in medicine liquorice is used much more as a flavouring agent in foods, beverages and confectionery.

In medicine decorthicated roots are used as medicinal tea. Liquorice extract is used in cough mixtures and tablets as an expectorant and anti-flammatory agent. It is also used as a demulcent in tinctures and syrups to mask the bitter flavour of certain ingredients.

As a flavouring agent liquorice is used in various types of tobacco, chewing gums, candies, beverages and confectionery.

Liquorice extract is used in fire extinguishers.

5. Consumers:

The main consumers of liquorice are U.S.A., Japan, France, Federal Republic of Germany and U.K.

Approximate import of roots in these countries is as follows:

1.	U.S.A.	2,900 tons
2.	Japan	900 tons
3.	France	300-500 tons
4.	West Germany	300-500 tons
5.	U.K.	1000-1500tons

In addition to the above countries, smaller quantities are imported by all countries in the world where this drug is not produced, and the market is expected to grow with industrialization of the third world.

Programme for Production of Liquorice in Kenya:

The drug can be introduced from India, Egypt or Iraq and should be tried at dry farming stations of Machakos and Baringo. Once it is found economical it can be recommended for cultivation in North Eastern Kenya and other dry areas of Kenya.

When large quantities are available an industry for production of concentrated liquorice extract and powder can be established.

Economics of Cultivation

		KShs.
1.	Field Preparation	200
2.	Planting	200
3.	Inter-culture	400
4.	Harvesting and drying	400
5.	Rent on land	100
	Total operating cost per hectare for 2 years	1,300
	Interest at the sale of 10%	100
	Total cost for two years	1,100
	Gross return in two years at the rate of KShs.10 per kg. for 1000 kg.	10,000

Net Return per hectare per year $\frac{10,000 - 1,100}{2}$

= 4,500 per year per hectare.

PERIWINKLE A POTENTIAL CROP FOR SEMI-ARID AREAS OF KENYA

Botany and Geographical Distribution:

Periwinkle Cathranthus roseus (Family Apocynaceae) a common garden plants is native to West Indies and Madagascar, but has become naturalized in all tropical and sub-tropical areas of Asia and Africa. Some of the countries where the plant is widely distributed and exploited are Madagascar, Mozambique, Israel, India, Sri Lanka and West Indies. It is also cultivated to a limited extent in Israel and India.

The plant has been used in traditional medicine in Jamaica and South Africa mainly as an anti-diabetic drug in form of tea. Intensive research on this plant during the last 15 years have shown that although it does not have any significant hypoglycaemic property, but the leaves have useful alkaloids which have anticancer properties. The roots or the plant also contain useful alkaloids which are used as vasodilators in modern medicine. It is because of these properties, that the plant has been adopted in modern medicine as a valuable raw material for these therepeutically important alkaloids.

Soil and Climate:

Periwinkle grows well in tropical and sub-tropical areas or areas having a mediterranean type mild climate. Light and medium soils which are neither acidic nor alkaline are suitable for the crop. Heavy clay soils and water-logged areas are not suitable. The Crop can easily grow on very poor soils and even in those areas where there is limited rainfall as it is fairly drought resistant. It can be cultivated even on steep slopes, rocky areas and on soils generally not suitable for high value food crops. In Kenya, Coastal Areas, Southern lowlands and even semi-arid areas in North Eastern Kenya (with a rainfall of 300 mm or more) are suitable for this crop.

Method of Cultivation:

Periwinkle is one of those crops which needs very little care. The seeds should be planted in nursery during the summer months of December and January about 500 gms. of seeds are sufficient to raise enough seedlings for one hectare of crop. 6 to 8 weeks old seedlings should be planted in the field during the month of March and April when the long rains are well set. The seedlings should be planted at a distance of 30 cms. in rows which should be 45 cm. apart. One or two weedings would be required to keep the crop free from weeds. Normally no fertilizer is required. However, in soils with very poor fertlity level, 40 kg. of nitrogen per hectare may be applied in two split doses during the early stages of growth, 6 and 12 weeks after planting in the field. The crops also does not require any plant protection measures.

Harvesting:

Two clipping of leaves can be obtained during the year on after 6 months and another after 8 months after planting. The crop including the roots and leaves can be harvested one year after planting. It is better to run a tractor with a cultivator and pick the plants along with the roots. The roots along with 3" of lower portion of stem should be cut, washed and dried in sun. The leaves should be dried in shade. Both the leaves and the roots can be packed in gunny bags for marketing. An average yield of 1000 kg. of roots and about 500 kgms. of leaves can be obtained from one hectare of the crop after one year of growth.

Active constituents and uses:

The various parts of plants which consist of roots, stem and leaves contain more than 100 alkaloids of which three are important in medicine.

The leaves of C. rosens contain two important anticancer alkaloids namely Vinblastin and Vincristin. However the actual quantity of the alkaloids in the leaves is very small (.002%). Vinblastin is used for treatment of leukemia Hodgkin's disease and other lymphomas, carcinomas, seminoma, and embroyonal tumors of the testes.

Vincristin is used in the treatment of acute Leukemia, Hodgkins disease, lymphosarcomas, carcinomas, astrocytomas, neuroblastoma, rhabdomyosarcoma and Wilm's toumor.

The roots are used mainly for isolation of one of the indole alkaloids, Ajmalicine (Rauhasine) which is used extensively in Europe as a vasodilater in various heart diseases. In fact the main value of the crop today is for roots which has more demand in Europe as compared to leaves.

World Trade and Future Prospects:

The world demand of C. roseus leaves is limited. Approximately 1,000 tons of leaves are imported in U.S.A., West Germany is the main importer of roots and approximately 800 to 1000 tons of roots are imported. Recently, Hungary has become a major importer of leaves, requiring about 500 to 600 tons of leaves annually. The suppliers of leaves and roots are Madagascar, India, Sri Lanka, Israel, Mozambique and West Indies.

Although demand of roots and leaves is limited as only a few companies in the world specialize in the manufacture of leaf and root alkaloid, consistant market can be assured if permanent arrangement for supply can be made with international houses. In Kenya experiments should be carried out to work out economics of cultivation specially in semi-arid areas as Periwinkle is not a very paying crop on good agricultural land. However, it can be very profitable on poor soils with less rainfall where it would give better returns as compared to grazing or raising of millets or other dry land crops.

Economics of Cultivation

1.	Field Preparation	KShs.	200.00
2.	Raising of nursery and planting	KShs.	200.00
3.	Interculture	KShs.	200.00
4.	Fertilizer application	KShs.	100.00
5.	Harvesting, drying and Packing	KShs.	300.00
6.	Rent on land	KShs.	100.00
	Total operational cost	KShs.	1,100.00
	Interest at the rate of 10%	KShs.	110.00
	Total cost of cultivation per hectare		1.210
		say KShs.	1,200.00
	Returns - Cost of 10,000 kg. of roots at the rate of KShs.4/- per kg.	KShs.	4,000.00
	Cost of 500 kg. of leaves at the rate of KShs.2/-per kg.	KShs.	1,000.00
	Total Return	KShs.	5,000.00
	Net Profit per hectare per year	5,000 - 1,200	
		= KShs.	3,800.00 .X.

.X. These returns are based on minimum price of roots. Generally roots fetch a price of KShs. 6 to 8 per kgm.

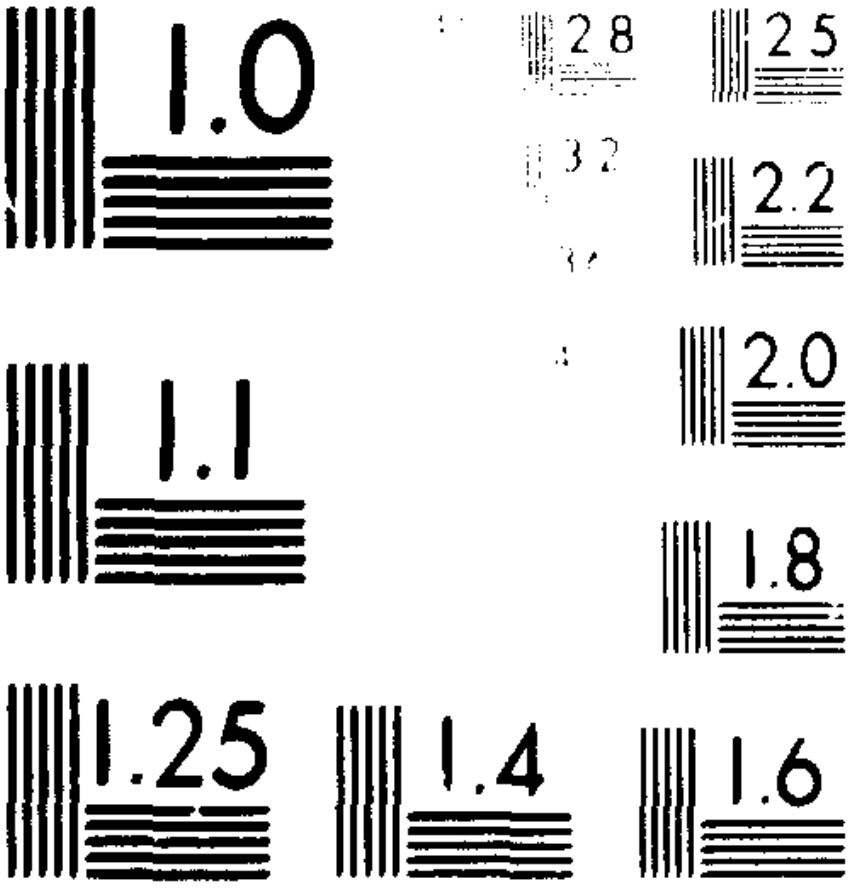
Important firms dealing with Cathranthus Roseus

1. Elilly & Co.,
740, South Alabama Street,
Indianapolis, Indiana 46206,
U.S.A. (Leaves)

2. Andard Mount Co. Ltd.,
Burlington Works,
Tudor Estate, Abbey Road,
London, N.W.10, U.K.
(Roots & Leaves)

3. John Ronaldson & Co.,
554, Grand Building,
Trafalgar Square,
London WC-2, U.K. (Roots & Leaves)

4. C.H. Boehringer Sohn,
6507, Ingelheim,
West Germany, (Roots & Leaves)


1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

LEMON GRASS, A POTENTIAL INDUSTRIAL CROPS FOR KENYA

Botany and Geographical distribution:

There are two types of lemon grass oils in the international market. East Indian Lemon grass oil is obtained from leaves of Cymbopogon flexuosus stapf. This species is indigenous to South India and is cultivated in Kerala and other humid tropical parts of India. The oil from East Indian grass is preferred in the international market because of its high citral content (80 to 90%). West Indian lemon grass oil is obtained from Cymbopogon citratus stapf. is indigenous to West Indies and is cultivated in Guatemala, Haiti, Argentina, Brazil, Tanzania, Congo, Madagascar, Comorin Islands and Thailand.

Climate and Soil:

Light and medium soils which are well drained are suitable for lemon grass cultivation. Heavy clay soils and water logged lowlands are not suitable for this crop. Lemon grass thrives well in warm, humid climate. However, the plant is highly adaptable and grows well under mild sub tropical climate in all areas where there is no frost.

In Kenya,coastal areas and South Nyanza are suitable for cultivation. It can be cultivated even on poor soils and very steep slopes where it serves as a soil conservation crop.

Method of Cultivation:

Lemon grass is multiplied both by seed as well as by vegetative propogation. Vegetative propagation is better for multiplying good clones and maintaining the purity of a particular strain.

In case of seed multiplication the seed should be first planted in a nursery in December or January. The seedlings should be planted in the field when the rains are well set in April and May.

In the case of vegetative propagation the clumps should be pulled up and then divided into single stems called slips. Slips or seedlings should be planted at a distance of 60 cm in rows which should be 60 cm apart. During rainy season no irrigation is required. However, if the crop is planted on a sunny day it is better to irrigate soon after planting. However, if the planting is done during long rains, irrigation would not be required.

The crop should be kept free from weeds in the initial stages by regular weeding and hoeing. Nitrogen at the rate of 60 kg. per hectare should be applied in three split doses during the first year and repeated in the second year.

The first harvest is ready approximately 6-8 months after planting and further harvests can be obtained after every 3 months. If the crop is planted in semi-arid areas irrigation would increase the yield during the rain free period. In case no irrigation is provided the crop, being drought tolerant would still survive and give a crop as soon as the rains start again. The plant is highly resistant to diseases and insect pests and generally no plant protection measures are necessary. Two to three weedings would keep the crop free from weeds as it is a week smothering crop.

Harvesting and Distillation:

The first harvest would be obtained after 3 months in case of plant being propagated from slips. In case of seed multiplication the first harvests can be obtained only after 6-8 months. The crop planted ones would give harvests for 7 - 10 years. When the crop is ready for harvest the leaves are cut 9" from the ground and distilled fresh in any direct first or steam operated still.

The distillation still consists of a tub, a condenser and an oil separator. In case of directly fired still or a field still which is needed by small farmers, a false bottom is provided near the bottom of the still and the lower part of still containing water serves as a boiler. It is better to provide iron cages with circular perforated bottom and iron chain for loading and removing the spent grass from the still. This cage can be easily operated by a manually operated chain pulley block.

For distillation the grass is packed in the still. Two or more cages may be required depending upon the size of the still. After the still is loaded the lid is closed, steam is allowed to pass through the grass either by direct firing or from a boiler. The steam while passing through the herb carries the oil vapour which gets condensed while passing through the condenser and finally gets separated and floats on the top in the separator. The oil can be either tapped off or scooped off from the separator. The crude oil and water mixture can be further purified by removing the excess water in a separating funnel.

During the first year a yield of 30 kg.. of oil can be obtained in one hectare of the crop which would increase to 50-60 kg. in succeeding years. In case of small plantation of 5 - 10 acre it is better to use a field still which can be easily designed and fabricated locally from 5 mm mild steel sheets. Wood or even the spent grass after the distillation of oil can be used as a fuel. The spent grass can also be used as a very good compost or mulch for other crops. It can be also used for making hand-made paper or board.

Active Constituents:

The leaves of lemon grass contain 0.3% to 0.6% of a volatile oil. The West Indian lemon grass (C. citratus)

contains more oil 0.5 to 0.6% as compared to East Indian grass (C. flexuosus) (.25 to .4%). Initial experiment in Kenya have shown that the oil content is higher and ranges from 0.5 to 0.6%. The main constituent of oil is citral.

A limited amount of oil is used directly in cheap soaps and household detergents. However the major production is used for isolation of citral. A part of citral is used in perfumery cosmetic and flavouring industry. Citral is also converted into Ionones which are starting material for a number of synthetic perfumery compounds. At present a large portion of lemon grass oil is converted into βionones which is used for synthesis of Vitamin A.

World Trade in Lemon Grass Oil:

The major producers of lemon grass are India and Gautemala which produce approximately 80% of total world demand. Other countries produce only smaller quantities. The production in different countries is as follows:

1. India	700 - 800	tons
2. Guatemala	600 - 700	tons
3. Argentina	50 - 60	tons
4. Brazil	50 - 60	tons
5. China (Mainland)	50 - 60	tons
6. Indonesia	10 - 20	tons
7. Thailand	10 - 20	tons
8. Malagasy Republic	10 - 20	tons
9. Comorin Islands	10 - 20	tons
10. Haiti	10 - 20	tons
11. Congo	10 - 20	tons
12. Tanzania	10 - 20	tons
13. Uganda	10 - 20	tons

The major importing countries of lemon grass oil are U.S.A. (600 - 650 tons) U.K. (250 - 300 tons) France (150 - 200 tons), U.S.S.R. (200 tons) and Japan (150 - 200 tons). A lot of lemon grass oil is consumed

inside the producing countries itself mainly for direct use in cheap grade perfumes or flavours and synthesis of ionones. India now exports more than half of its produce as ionones.

Prices and Future Market Prospects:

The current world price of lemon grass is approximately KShs.75/- per kg. (World Cosmetic news: July 1980). The prices have been increasing for the last 10 years and at one time these ranged from KShs.15 - 20/- per kg. when synthetic ectrail which is derived either from Turpentine or petroleum products was available at a cheaper price than natural ectral. Because of unprecedented increase in the price of petroleum and Turpentine oil the entire pharmaceutical industry has switched on to production of Vit.A from lemon grass oil. The world pharmaceutical industry is using synthetic citral today only because enough lemon grass oil is not available specially because of decrease in production of lemon grass oil in India. At one time India was producing about 1500 tons of oil in 1954 and now this production has gone down to 700 to 800 tons. Moreover India has now its own perfumery industry and a considerable portion of its oil is consumed inside the country. As soon as India's Vit.A plant is commissioned there would be very little of Indian lemon grass oil available for world market. The only other substitute of lemon grass oil is Litzea cubeba oil from China which is being used as a source of citral in Europe. However the supply of this oil is limited. With further improvement of standard of living in the third world the demand - of lemon grass oil both for perfumery and Vit.A is going to increase. Any new country which can produce lemon grass oil would find a ready market in Europe, Japan and U.S.A.

Kenya itself has a prefumery industry mostly under the control of multi-national all of which import their requirement of lemongrass oil and its products from abroad. Production of the oil in this country would result into saving of valuable foreign exchange.

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4. Guenther. E. 1949 The essential oils vol.IV D. Van Nowstand Co. Inc. Princton, N.J. U.S.A.

5. Cosmetic World News June-July 1980.

International Buyers of Lemon Grass Oil

1. Bush Boak and Allen Ltd.,
   Blackshire Lane,
   LONDON E.17 U.K.

2. Gale and Mount Ltd.,
   Commerce Road,
   Brentford,
   Middlesex U.K.

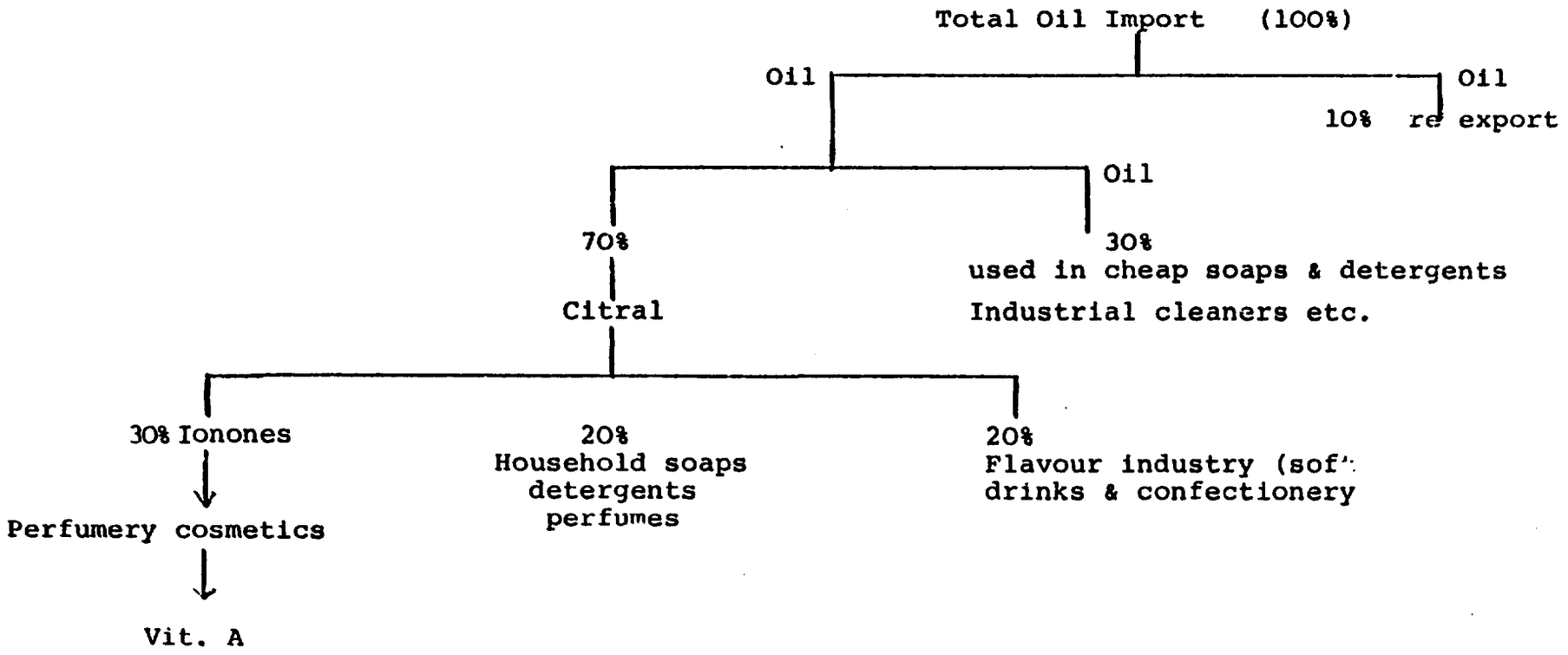
3. R.C. Treat and Co. Ltd.,
   19, Wattling Street,
   London U.K.

4. Blyth Green Jourdain,
   Plantion House,
   Fenchurch Street,
   London EC3. U.K.

5. Volkart Brothers,
   29, Mincing Lane,
   London EC3 U.K.

6. W.H. Hobb & Co.
   166, Tower Bridge Road,
   London S.E.1 U.K.

USE OF LEMON GRASS OIL *



* Based on use of imported lemon grass oil in U.K.

ECONOMICS OF CULTIVATION

1st Year

1.	Field Preparation	K.Shs. 300.00
2.	Planting	K.Shs. 300.00
3.	Inter-culture	K.Shs. 200.00
4.	Fertilizer application	K.Shs. 200.00
5.	Harvesting	K.Shs. 400.00
6.	Cost of distillation at the rate of KShs.20/- per kg. (50 x 20)	K.Shs.1,000.00
7.	Rent on land	K.Shs. 100.00
	Total operational cost 1st year	K.Shs.2,400.00
	Interest at the rate of 10%	K.Shs. 240.00
	Total cost first year	K.Shs.2,640.00
		or say 2,600.00
	Cost of cultivation in succeeding 4 years (less by 20% than 1st year)	K.Shs.2,000.00
	Average cost per year per hectare	$\frac{2000 \times 4 + 2,600.00}{5}$
		approx. 2,100.00
	Gross return at the rate of KShs.75 per kg. of oil (Average yield 50 k.g.)	4,750.00
	Net Profit per year per ha.	4750 - 2,100.00
		= KShs. 2,650 *

*This is an average return. Return as high as KShs.4,000.00 can be obtained under ideal conditions of crop management.

CITRONELL A PROFITABLE ESSENTIAL OIL CROP FOR KENYA

Botan, and Geographical Distribution:

There are two types of citronella oils in the international market. Celone type citronella oil is obtained from Cymbopogon nardus. The plant is indigenous to Celone and cultivated there to a limited extent. This oil is considered as an inferior oil because of its poor alcohol content (55 -65%) and has only a limited market.

Java type citronella oil is obtained from Cymbopogon winterianus. Most of the citronella oil of commerce comes from this species and it is cultivated in Indonesia, Formosa China, Guatemala, Brazil, Argentina and India. Java type oil is preferred in international market because of its higher alcohol and 85 to 95%) and aldehyde content (35 - 50%).

Soil and Climate:

Citronella grows best in deep fertile soils which are light to medium and free from water logging. It prefers a p^H range of 5 to 7.5. High alkaline or acid soils are not suitable for this crop. Warm humid climate with plenty of well distributed rainfall is ideal for optimum growth of citronella. However, citronella can be cultivated profitably in all-tropical and sub-tropical areas where irrigation can be provided. Mild warm temperatures without frost is suitable for oil synthesis.

In Kenya, coastal areas, southern lowlands and lower elevations of rift valley and South Nyanza are suitable for cultivation of this crop. It can also be cultivated in lower elevation of semi arid areas where irrigation can be provided during rain free period.

Method of Cultivation:

Citronella is propogated vegetatively through plantlets or stem cuttings called slips. The entire clump of at least one year old plant is pulled up and

stem pieces along with the roots are divided into single stems called slips. Fifty to 150 slips can be obtained from one single clumps depending upon age of plant and stage of growth.

Although citronella can be planted any time in Kenya, best results can be obtained if the crop can be planted during the long rains preferably between March to May. Field should be ploughed and harrowed so as to get a fine tilth. All the weeds and stubbles should be removed so as to avoid weed competition after the crop is planted. The slips should be planted at a distance of 60 cm in rows which should be 60 cm. apart. In areas where there is danger of water logging it is better to plant citronella on ridges made at a distance of 60 cm.

In case of soils which are deficient in Phosphorus and Potassium. P_2O_5 and K_2O at the rate of 30 kg. per hectare should be applied as a basal dressing before planting. Nitrogen at the rate of 20 kg. per hectare should be applied as top dressing about six weeks after planting. This dose should be repeated after a period of 3 to 4 months. 100 kgns. of nitrogen at an interval of 3 months should be applied in suceeeding years. It is always better to apply nitrogen after the crop starts sprouting after every harvest.

Hoeing and weeding has to be done periodically to keep the crop free from weeds specially in the initial stages after which the crop smothers the weeds.

Harvesting and Distillation:

The crop would be ready for harvesting 4 - 6 months after planting in areas with well distributed rainfall or where irrigation facilities are available. In semi-arid areas where citronella is grown as a rain-fed crop the first harvest would be obtained only

after 6-8 months. In all areas more soil moisture is plentiful, one harvest would be obtained every third month after the first harvest. As such in coastal or other humid areas of Kenya 4 crops could be obtained every year under proper crop management practices.

At the time of harvesting leaves are cut manually with a sickle (0-12" above the ground level. Care should be taken not to cut the crop too close to the ground level. The leaves can be distilled fresh or allowed to wilt for 6-8 hours-before charging in the still.

Distillation of citronella is carried out in direct fired field still or Boiler operated stills in a manner similar to lemon grass oil. Steam distillation by using a boiler always gives better results as both quantity and quality of oil obtained is better.

A hectare of good crop of citronella would give 50-75 kgm of oil during the first year and 100 to 150 kg. oil per hectare during succeeding 2 to 3 years. Under good care and management, eitronella planted once would give good crops for 3 to 4 years and yields as high as 250 kg. per hectare can be obtained specially under intensive agriculture on small farms.

Active Constituents and Uses:

Citronella leaves on steam distillation give 0.7 to 1.3% of an essential oil which has got rich and pleasant odour. The main constituents of the oil are Gerianol, citronellol and citronellal. Celone citronella contains less alcohols (50-60%) and aldohydes (7-15%), as campared to Java citronella which is rich both in total alcohol (75 to 95%) and aldehydes (35-50%).

Celone citronella is used mainly for scenting cheap grade soaps and detergents. Java citronella oil is used for isolation of perfumery chemicals like gerianol, citronellal hydrosxy citronellal and other derivatives

which are used extensively in perfumery and cosmestics. To a limited extent java citronella oil is also used directly in soaps, detergents and anti-mosquito repellent creams.

World Market and Future Prospects:

The present exporters of citronella oil in the world are Formosa, Indonesia, China (mainland) Guatemala and Celone. In other countries which produce 50 - 60 tons, most of the production is consumed locally. The major importers of citronella oil are, U.S.A., (1000.00 tons) Japan (900-1100 tons). U.K. (250-500 tons) France (600 tons).

During the last few years the demand of citronella has been increasing and consequently there has been considerable esclation in prices. The international market price of java type citronella which used to be around KShs.40-45 per kgms. has gone upto around KShs.80/- per kg. (July, 1980) both in New York and London markets. According to market forecast (Chemical Marketing Reporter, New York) the prices would increase further as prices of synthetic perfumery materials is going up. As such there is considerable scope for production of citronella oil by any country, specially when one considers the demand in Eastern Europe and Asis and Africa where the demand for perfumery raw material is bound to increase with indigenous production of perfumes and cosmetics.

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IMPORTANT FIRMS DEALING WITH CITRONELLA OIL

1. R.C. Treat & Co. Ltd.,
   19, Watling Street,
   London E.C.4
   U.K.

2. Bush Boak Allen Ltd.,
   Blackhorse Lane,
   London E.C.4
   U.K.

3. Gale Mound Ltd.,
   Commerce Road,
   Brentford,
   Middlesex,
   U.K.

4. Blyth Green and Jourdani Ltd.,
   Plantation House,
   Mincing Lane,
   London EC3,
   U.K.

ECONOMICS OF CULTIVATION

1ST YEAR

1.	Field Preparation	KShs.. 300
2.	Planting	KShs. 300
3.	Inter-culture	KShs. 500
4.	Fertilizers	KShs. 600
5.	Irrigation (Semi-arid areas)	KShs. 300
6.	Harvesting	KShs. 300
7.	Distillation at the rate of KShs.10/-per kg. an average yield of 150/kgm. of oil per hectare.	KShs.1,500
8.	Rent on land	KShs. 100
	Total operational cost	KShs.3,800
	Interest at the rate of 10%	KShs. 380
	Total cost of cultivation per hectare in the first year say	KShs.4,180 KShs.4,200
	Cost of cultivation in succeeding 3 years (20% less than 1st year)	KShs.3,500
	Average cost per year $\frac{(3 \times 3500 + 4200)}{4}$	= 3,675 say KShs.3,700
	Gross return per year at the rate of KShs.80/- per kg. of oil (150 x 80)	KShs.12,000

Net return per hectare per year (12,000 - 3,700)

= KShs.8,300 *

* This is an average figure. Returns as high as KShs.12,000 can be obtained under ideal condition of cropping.

PACHOULI A POTENTIAL ESSENTIAL OIL CROP FOR HUMID TROPICAL AREA OF KENYA

Botany and Geographical distribution:

Oil of Pachouli is obtained from dried and cured leaves of Pogostemon pachouli (Syn. Pcablin). The plant is a native of Indonesia and cultivated in Indonesia, Malaysia, Seychelles islands and China.

Soil and Climate:

Deep fertile and medium soils with ample drainage are suitable for Pachouli cultivation. Heavy clay soils or soils with high acidity and alkalinty or those soils with poor drainage should be avoided.

Warm humid climate with ample rainfall which is well distributed is suitable for this plant. In Kenya coastal areas and warm humid areas in western Kenya are suitable for cultivation of Pachouli.

Method of Cultivation:

Pachouli is propagated vegetatively through stem cuttings. About 9" cuttings with 3 to 4 terminal leaves are taken from a vigourously growing crop. In Kenya it would be advisable to take the cuttings during early rains in March and plant them in nursery. The cuttings should be planted in sand in raised beds under the shade of a tree. These should be irrigated frequently to keep sufficient moisture in the bed. Treatment of the cuttings with any standard rooting hormone would encourage early establishment of cuttings. Use of a mist chamber in place of ordinary nursery bed would cut down the time of establishment of cuttings. Four to six weeks old rooted cuttings should be planted in the field at a distance of 60 to 75 cm. in rows which should be 60-75 cm apart. Pachouli thrives best under shade and therefore it is advisable to plant this crop as an inter crop in coconut or cashewnut plantations. Most of the Pachouli crop in the world is grown as an inter crop with coconut. Whenever, coconut is not cultivated in quick growing tree

should be planted before the crop is planted in the field. In soild infested with roct knot, some nematocide like nemagon should be applied in rows 2 weeks before planting.

After the plants are established nitrogen at the rate of 60 kg. per hectare should be applied in three split doses. The crop should be kept free from weeds by regular weeding and hoeing.

Harvesting and Distillation:

The first harvest of pachouli can be obtained approximately six months after planting when all the terminal branches along with the leaves are harvested. The leaves should be dried in the shade with frequent turning till they develop typical odour, characteristic of pachouli oil. The fresh leaves have very little scent but the odour develops after the leaves are dried and cured.

The dried leaves should be distilled in an steam operated still preferably under high pressure. The distillation is continued for 6-8 hours in order to recovers all the oil. A hectare of crop would give approximately 30 kg. of oil during the first year and 50-60 kg. of oil in succeeding years. The crop planted once can give good harvest for 3-4 years. Normally 3 to 4 harvests of leaves are obtained every year. specially in areas where moisture is optimum and atmospheric humidity is high.

Active constituents and uses:

Dried leaves of Pachouli contain approximately 2 to 2.5% of an oil which is used directly in perfumery and cosmetic industry. Although various terpene constituents of Pachouli oil have been analyzed, there is no single constituent which can give the typical odour value of pachouli oil. As such this oil has no

synthetic substitute and the oil finds wide use in almost all perfumery and cosmetic preparations. The oil provides tenacity to odour and is used as fixative. Most of the perfumes of oriental nature contain Pachouli oil. It is also used in soaps and cosmetics as a fixative.

World trade and Future Prospects:

The main Pachouli oil producing countries are Indonesia (230 - 250 tons) Malaysia (150 tons and Seychelles islands (25 tons). The major consumers and importers of Pachouli oil are U.S.A. (150-160 tons) Japan (45-50 tons), U.K. and France. Other countries like Netherlands, Belgium, Italy, U.S.S.R., and India import small quantity.

The production of Pachouli oil has been more or less static and in fact the Indonesian production has gone down during recent years. The demand for Pachouli oil has been increasing specially because of development by perfumery and cosmetic industries in the Communist world and developing countries.

As such there is considerable scope for production of Pachouli oil in other countries like Kenya where soil and climatic conditions are suitable for this crop.

Proposed for Production of Pachouli Oil in Kenya:

Pachouli should be introduced either from Seychelles Island, Indonesia or India and tried initially on experimental scale at the coastal Agricultural Research Station as an intercrop in Cashew, Mango and Coconut plantations. If the experiments are successful, it can be popularized with farmers who can get an additional cash income from their coconut plantations.

ECONOMICS OF CULTIVATION

Field Preparation	KShs. 200.00
Cost of raising nursery	KShs. 100.00
Planting	KShs. 100.00
Hoeing and weeding	KShs. 300.00
Fertilizer application	KShs. 200.00
Harvesting and drying	KShs. 200.00
Distillation at the rate of of KShs.30 per kg. of oil (at the rate of 40 kg. of oil per hectare.	KShs.1,500.00
Rent on land	KShs. 100.00
Total operating cost per hectare per year	KShs.2,700.00
Interest at the rate of 10%	KShs. 270.00
Total cost of cultivation per ha.per year	KShs.2,970.00
	say KShs.3,000.00

Average return per hectare per year (at the rate of 40 kg. of oil per ha. per year and price of KShs.300 per.kg.) 300 x 40 = KShs.12,000.00

Net profit per year = 12,000 - 3,000
per hectare = KShs.9,000 per ha.