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UNITED NATIONS INDUSTRIAL
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MOBILE UNIT OF PHARMACEUTICAL AND ESSENTIAL OILS INDUSTRY TO THE LEAST DEVELOPED COUNTRIES IN ASIA

Phase I

AFGHANISTAN AND NEPAL

RP/RAS/76/009

Mission report

Based on the work of Ovidiu Bojar, medical plant expert, Adrian Iuganu, expert in vegetal extraction, and Ion Minea, medicinal plant expert

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Explanatory notes

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

References to dollars indicate United States dollars, unless otherwise stated.

The monetary unit in Afghanistan is the Afghani (Af). During the period covered by the report, the value of the Af in relation to the United States dollar was US$ 1 = Af 46.00.

The monetary unit in Nepal is the Nepal rupee (NRs). During the period covered by the report, the value of the NRs in relation to the United States dollar was $US 1 = NRs 12.45.

ABSTRACT

Within the framework of the UNIDO programme for the promotion of medicinal herbs and their use in medioine in the least developed oountries, the Joint UNIDO/Romania Centre sent an exploratory mission to Afghanistan and Nepal to collect data about available medicinal herbs and to make preparations for a mobile unit which would follow up the exploratory work. Three experts undertook the mission, which lasted from 31 January to 22 February 1977, and which was the first part of the project entitled "Mobile Unit of Pharmaoeutioal and Essential Oils Industry to the Least Developed Countries in Asia" (RP/RAS/76/009).

The main conolusions and reoommendations of the mission are given below.

A. Afghanistan

Conclusions

(a) There is a need for quantitative assessments of the medioinal herbs which could be harvested and collected in the main floral basins, taking into account the eoological implioations, and for qualitative evaluation of the active principles in the respeotive medicinal herbs. These tasks oould be performed by the proposed mobile unit;

(b) Medium-skilled labour is available, but there is a need for training in medicinal herbs prooessing. Such training oould be organized looally, whereas training for skilled personnel would be needed abroad.

Reoommendations

(a) The activity of the mobile unit, whioh would find the April-June period the most suitable time for beginning its work, should foous on essential oils, tanins, tinctures and alkaloids, beoause in a first stage these products would be prooessed in small-soale pharmaoeutioal units based on teohnologies whioh are not highly sophistioated;

(b) A oorporation or assooiation of farmers should be organized to guide and oontrol medioinal herbs exploitation, and suitable training programmes in medioinal herbs prooessing should be established both locally and abroad.

B. Nepal

Conolusions

(a) There is a need for eoonomio mapping of some speoies of spontaneous flora and for international assistanoe in the improvement of the methodology of obtaining and oontrolling essential oils from herb orops and in the extraotion of essential oils from medioinal herbs whioh are widely spread in the sponta-neous flora;

(b) Various possibilities exist for the substitution of certain imported raw materials, finished produots or aotive prinoiples by similar local produots.

Recommendations

(a) Urgent assistanoe should be provided in the form of experts, equipment and ohemioals in order to promote the produotion of medioinal plants and raw materials for the pharmaoeutioal industry;

(b) The first objeotives of the experts sent to Nepal should be methodologioal demonstrations with a view to drawing up eoonomio maps of medioinal herbs, laboratory assistanoe in obtaining multiplioation material for the produotion of ergot of rye with a high oontent of alkaloids and in testing alkaloids and essential oils and teohnologies, and assistanoe in the improvement of the teohnology of atropine extraotion.

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INTRODUCTION

The development of traditional medicine based on available medicinal plants in developing countries is one of the important objectives of UNIDO. The use of medicinal plants in developing countries has always been known, and 50% of the population of these countries use extracts or dry herbs for curing many tropical and epidemic diseases. Due to the increase in demand for medicinal drugs throughout the world, it seemed appropriate to consider the possiblity of producing such drugs more economically, particularly in developing countries, which have considerable natural resources and potential in this field. Consequently, within the framework of the 1976 work programme of the Joint UNIDO/Romania Centre, it was planned to send a mobile unit for the pharmaceutical and essential oils industry to the least developed countries in Asia. The project, entitled "Mobile Unit of Pharmaceutical and Essential Oils Industry to the Least Developed Countries in Asia" (RP/RAS/76/009), was to consist of two parts. The first would be an exploratory mission to collect data and information about available medicinal plants and their locations in the countries in question, and to prepare guide-lines for the work of the mobile unit which would follow up the exploratory mission. This report covers the first part of the project.

Based on the results of the first mission, the mobile unit will be sent to the countries involved, specifically Afghanistan and Nepal, to collect and extract the active principles from medicinal herbs and to introduce them into the pharmaceutical industry. Its operations are expected to last six or seven months, and the results of the analyses carried out by the team of experts on the available herbs in the countries visited, together with conclusions and proposals, will be submitted to UNIDO for further action. At the same time, a programme for training technicians on site could be organized. The mobile unit's stay in each country could therefore be extended for training local technicians if the Governments are interested in this possiblity.

This report describes the activities and presents the findings and recommendations of the exploratory mission to Afghanistan, which took place 31 January to 12 February 1977, and to Nepal, which lasted from 14 February to 22 February 1977.

I. MISSION TO AFGHANISTAN

In order to collect basic information concerning the current state and development prospects of the medicinal herbs industry in Afghanistan, the experts made a thorough study of the available documentation (in this connection, see annex I) and visited various institutions and government departments, a state farm and a manufacturing concern. These visits produced the findings described below.

Ministry of Public Health

The Minister of Public Health expressed to the experts his interest in the UNIDO programme in the field of pharmaceutical and essential oils industries based on the national resources. In particular, he emphasized the following points:

(a) In Afghanistan it is an old tradition to make use of medicinal herbs, which are available in large quantities and varieties;

(b) Substantial quantities of medicinal herbs are exported, especially to India and Pakistan;

(c) Other experts (from France, India, Japan and the Union of Soviet Socialist Republics) had carried out studies which confirmed the existence of medicinal herbs in certain regions of Afghanistan, but no complete data and surveys are available on the quantity and the quality of this natural resource;

(d) It is very important to explore the possibility of replacing imported pharmaceuticals by locally manufactured medicines containing extracts from indigenous medicinal herbs.

In conclusion, the Minister of Public Health promised his support for the second phase of the project.

Institute of Public Health

The Institute belongs to the Ministry of Public Health and is provided with, among others, a drug-control section, a bacteriological laboratory and an inframicrobiological laboratory. These laboratories are being currently reorganized and can be used for testing the active principles of medicinal herbs, but they are not sufficient. With regard to chemical reactives and solvents, there are not enough quantities and assortments available to perform chemical investigations.

The Institute has a general collection of plants which may form the nucleus of a herbarium, but the plants are not yet identified and localized.

The President of the Institute expressed partioular interest in the UNIDO programme and offered his support by providing the necessary staff and offering the use of the faoilities of his laboratories to the extent that the equipment is adequate. At the same time, the President of the Institute stressed the following needs:

(a) Training programmes for his staff, possibly as fellowship holders, organized by UNIDO in oountries with substantial experienoe in the processing of medioinal herbs. Training and demonstration programmes would also be neoessary during the second phase of the projeot in Afghanistan;

(b) Assistanoe in the organization of the herbarium of the Institute.

From an eoonomio and technioal point of view, the President of the Institute considered the three groups of aotive principles proposed by the experts (essential oils, tanins and alkaloids) of prior interest during the mobile unit activity.

It was emphasized that the best periods for performing the tests on medicinal herbs are April-June and September-Ootober, espeoially for alkaloids extraoted from roots and for essential oils from buds.

Kabul University, Faculty of Pharmacy

A professor at the University drew the experts' attention to the following:

(a) The existenoe of a oertain researoh aotivity oarried out on Afghanistan flora, although little data was available ooncerning medicinal herbs;

(b) The intention to set up a quality standardization centre for plants and drugs;

(o) The intention to set up a laboratory for essential oils;

(d) The Factulty's laok of proper laboratory equipment and reagents.

The professor referred to is president of a new oompany, Afghan Plant, which will make use of medioinal herbs and promote starch exports. He expressed partioular interest in the implementation of the UNIDO programme for promoting the use of medioinal plants, and agreed that the best period for the second phase of the programme would be April-June and that one or two persons would be made available to assist the UNIDO experts if they were provided with a reasonable per diem.

Ministry of Agriculture

The President of the Forestry Department noted the intention of the Ministry of Agriculture to establish medium-sized tree plantations in order to prevent soil erosion and to develop sources of medicinal extracts. The Ministry is also drawing up a map showing the distribution of vegetation in Afghanistan.

The head of the Forestry Department expressed his support for the implementation of the UNIDO programme.

Ministry of Commerce

During discussions at the Ministry of Commerce the following points were stressed:

(a) There is no suitable organization for the cultivation, harvesting and selection of medicinal herbs in Afghanistan;

(b) The collection and export of medicinal herbs are undertaken by small dealers. In this respect, the Ministry of Commerce intends to set up a corporation of producers with a view to promoting the production and export of medicinal herbs;

(c) Two projects for the extraction of liquorice have been organized, but they have not yet been implemented.

It was also pointed out that the export of medicinal herbs could not be promoted due to the lack of adequate studies of the quality and quantity of such herbs, although there are about a dozen rich districts in Afghanistan.

In 1976 the following plants and drugs were mainly exported: Asafoetida, Plantago psyllium, Pimpinella anisum, Coriandrum sativum, Glycyrrhiza glabra, Carum carvi and Cuminium ciminum. The total value was estimated at about US$ 7 million, but there were no reliable data concerning total exports, and it is considered that they might be higher.

The development of the export of conditioned herbs and extracts is regarded as possible. The setting up of a small-scale extract industry would be possible only with external assistance. The richest regions of Afghanistan in medicinal herbs are in the north and north-east (comprising about 10 districts). It is therefore necessary to continue the UNIDO programme in the second phase of the project.

Field trip to the state farm in Jalalabad

The government farm in Jalalabad, with an area of 330 ha, was established with the assistance of the Union of Soviet Socialist Republics, and is currently operated by Afghan experts (agronomists, technicians and 270 workers). The farm is provided with the necessary equipment and irrigation system. The main plantations produce oranges, olives, lemons, grapefruits and eucalyptus. The productivity of this farm is high, and there are other similar state farms in Afghanistan. In this connection, the experts consider it possible to establish similar farms for the production of medicinal herbs which could form a sound basis for the establishment of a pharmaceutical industry.

Avicenna Pharmaceutical Institute

The Avicenna Pharmaceutical Institute is a semi-autonomous profit-making government enterprise with the following main functions:

(a) Preparation and provision of drugs, medical instruments and supplies needed in hospitals and health institutes throughout the country;

(b) Production of drugs and pharmaceutical preparations in accordance with the standards of international pharmacopoeias;

(c) Holding a monopoly of some drugs, such as medicinal alcohols and narcotics;

(d) Authorizing local producers and wholesalers to produce and import drugs in accordance with international pharmacopoeias;

(e) Development and expansion of laboratory facilities for the production of pharmaceuticals.

The Institute includes the following bodies: the General Authority, the Operative Committee and the Supervisory Committee. The General Authority in the Institute is the Ministry of Public Health.

From the discussions it emerged that some drugs are laboratory conditioned at the Institute in the form of tablets, capsules (with antibiotics), ointments and syrups, and that some tinctures are prepared on the basis of imported extracts such as Rhei, Valerianae, Chinae, Aurantiorum, Gentianae, Lobeliae, Nucis vomicae, Digitalis, Eucalypti, Cinammomi, Belladonnae, Aconiti, Syr. vittamini, Syr. Aurantiorum, Liqor ammoni anisati, Syr. Tolu, Syr. Ipeca and Syr. simplex. Total output is approximately 12,000 l/year.

The experts consider that part of these tinctures and syrups could be prepared on the basis of local medicinal herbs. The tinctures and syrups produced cover the needs of only 18 chemists' shops, but there are more than

30 importers which supply the other chemists' shops. The existing tableting capacity of the Institute will be expanded in the near future, and it is therefore worth considering the possiblity of using a part of this capacity for the local manufacture of pharmaceuticals based on indigenecus medicinal herbs.

The starch required for the manufacture of tablets is imported, although starch-containing drugs could be produced in Afghanistan (Indian corn, rice). Pharmaceutical ethyl alcohol can also be obtained from the starch-containing drugs.

The President of the Institute expressed some reservations about the profitability of herbs extraction (active principles).

Industrial Development Bank of Afghanistan

The General Manager of the bank outlined the investment prospects in Afghanistan industry.

With regard to the setting up of a pharmaceutical industry based on medicinal herbs, the opinion was expressed that no complete studies of the quantity and quality of indigenecus medicinal herbs have so far been made. The studies that had been carried out concerned neither the quantities nor the contents of active principles. However, Afghanistan is one of the biggest exporters of liocrice (Glycyrrhiza glabra), with exports totalling approximately 15,000 tons/year, and most of it comes primarily from the spontaneous flora in the north-west regions of the country, in particular from Her at and Badghis. Liocrice extract is mainly used in the pharmaceutical and tobacco industries.

The experts were also told of a liocrice-processing project with the participation of the Macandrews & Forbes Company (United States), which seems to be the main purchaser of the product.

The project was initially approved by the local authorities but has been stopped. The reasons set forth by the Ministry of Agriculture to explian the cancellation of the project concern its ecological aspects, in particular soil erosion in case of intensive exploitation of liocrice roots as raw material for a local processing unit. It should be noted, however, that the collection of liocrice for export continues.

It seems that the local authorities promised to reconsider the cancellation of this project, but no favourable decision has yet been taken in this respect. The experts consider it possible to apply to the cultivation of liquorice scientific methods which would eliminate its harmful ecological effects.

Finally, the General Manager expressed his support for the setting up of a local industry based on medicinal herbs.

Hoechst Afghanistan AG

Hoechst Afghanistan AG manufactures conditioned medicines and cosmetics from imported materials. The Managing Director expressed the view that only two medicinal herbs could be considered as a material basis for a pharmaceutical industry: papaver somniferum and Glycirrhiza glabra. The other existing medicinal herbs in Afghanistan are spread over large areas and are consequently very difficult to collect. With regard to the extraction of essential oils from conifers and citrics, the Managing Director considered that an industry could not be established, as the former are spread over large areas and the latter are limited in quantity and found only in the Jalalabad district.

It is worth noting that the operators in the Hoechst factory were recruited from the local population and were adequately trained.

II. MISSION TO NEPAL

During the mission the experts held a series of consultations with various officials and persons active in the field of medicinal herbs production in Nepal. The results of these consultations are described below.

UNDP Office, Katmandu

The following points emerged from discussions held at the UNDP office in Katmandu.

The exploitation and preservation of medicinal herbs is co-ordinated by the Department of Medicinal Herbs, which forms part of the Ministry of Forests. Research activity in the field of medicinal herbs is co-ordinated by the Royal Research Laboratory. There is one factory for drugs in Nepal, namely Royal Drugs Ltd, which is government-owned. It was therefore agreed that fact-finding visits to these bodies should be included in the mission's programme of activities.

The view was expressed that Rauwolfia serpentina, Atropa belladonna, Papaver somniferum (for codeine), Adhatoda vasica, Dioscorea sp. are of priority interest.

There is no centralized complete record of the amount of imported medicines, most of which are obtained from India.

There is clearly a need for practical demonstrations to acquire adequate technologies for the processing of medicinal herbs in pilot plants.

A copy of the study "Production of colophony and turpentine oil from the oleoresin of coniferous trees", by Mr. Joklik, a UNIDO expert, was available for examination.

Department of Medicinal Herbs

The Department of Medicinal Herbs co-ordinates the activities of the Royal Drug Research Laboratory, the Herbal Farms, the Royal Botanical Garden, and the Botanical Survey and Herbarium.

The Royal Drug Research Laboratory carries out research on medicinal herbs obtained from spontaneous flora and herbal crops and comprises the Drug Research Division, the Technology Development Division, and the Quality Control and Analysis Division.

The Drug Research Division has the following sections:

(a) Pharmacognosy section, where medicinal herbs are studied with a view to their standardization and histochemical classification;

(b) Plant Chemistry section, where the phytochemical screening of medicinal herbs is studied with a view to their use in therapeutics;

(c) Microbiology section, which carries out research on the antibacterial activity of drugs against different pathogens;

(d) Pharmacology and Biochemistry section, which tests the pharmacodynamic action of herb extracts.

The Technology Development Division is concerned with the isolation of the active principles of herbs.

The Quality Control and Analysis Division has three sections:

(a) Quality Control section, which analyses medicines, intermediate products and raw materials received from Royal Drugs Ltd;

(b) Market Survey and Analysis section, which analyses the various groups of medicines sold on the market;

(c) Public Analysis section, which analyses and standardizes miscellaneous samples received from government and private bodies.

The experts visited the divisions and sections of the Institute. It is well equipped with research apparatus, but certain solvents and reference substances and some equipment needed in pilot plants for the extraction of active principles are missing. The experts also noticed that for some of the research and pilot stages it is necessary to apply modern technologies and to obtain technical assistance.

Discussions held with the management and specialists of the Institute confirmed the need to develop the UNIDO programme in the field of medicinal herbs and to grant immediate technical assistance during the current year.

Based on the consultations held and the information gathered, the experts consider that follow-up action should focus on the objectives indicated below.

Economic mapping

There is a need for the economic mapping of some important species of spontaneous flora, namely: Aconitum palmatum, A. Heterophyllum, A. balfourii, A. spicatum or other species of Aconitum, Acorus calamus, Artemisis sp., Dioscorea deltoidea, D. Belophylla, Ephedra gerardiana, Nardostachys jatamanshi, Gentiana sp., Paris polyphilla, Piprorhiza sp., Rheum emodii, Rosa sp., Valeriana sp., Xanthoxylum armatum, and other species existing in large quantities.

The purpose of drawing up an economic map is to establish the exploitation zone of the natural resources, bearing in mind the ecological aspects and the content of the active principles. Technical assistance will be needed for establishing the methodology and carrying out some practical field work (especially during the August-October period).

Essential Oils[1/]

There are to important activities which require UNIDO assistance and the collaboration of the Institute's specialists. They are as follows: Methodology improvement for obtaining and controlling essential oils from herb crops such as Pyrethrum cinerariefolium, Cymbopogon citratus, C. martinii and Cymbopogon wintherianus, and for deriving pure natural menthol from Oleum Menthol obtained from Mentha arvensis and X-Mentha piperita; extraction of essential oils from medicinal herbs which are widely spread in the spontaneous flora, especially Artemisia sp. and Gaultheria fragrantissima.

The experts also consider important the experimental extraction up to the pilot scale of some essential oils with a rich content in alpha-pinen, beta-pinen and D-camphen from the conifer needles and branches obtained as a result of present and future forest exploitation. Mobile units are expected to be set up to accompany the conifer-tree exploitation teams. It should therefore be possible to find ways of putting to good use scrapings from log shaping, tree branches, fir cones and young branches with gemma or needles.

With regard to the second phase of the UNIDO programme when a mobile unit will be sent to the zone, the technical assistance should focus on demonstrations designed to obtain higher yields of essential oils from herbs processing and on chemical analyses of fresh harvest crops using testing equipment moved to the various areas concerned.

Ergot of rye

A number of tests and experiments were carried out on ergot of rye in the Royal Drug Research Laboratory, but no satisfactory results have yet been obtained. In view of the importance of such tests it is necessary to grant adequate technical assistance, to provide specific equipment and to obtain the necessary reagents (see annex III).

Technical assistance is required in the following fields: growing of Clavioeps purpurea mushroom on nutritive media in the laboratory until conidia is obtained as a multiplying material; rye agrotechnics and the growing of

1/ In this connection, see annex IV for two analysis bulletins.

ergot of rye by artificial infections in the field; selection of alkaloid stems by using indigeneous raw materials.

Technological improvements

There is a need for improvement of the technology applied in pilot plants for obtaining atropine from Atropa belladonna and other alkaloids from indigeneous raw materials.

In the existing pilot plant the atropins sulphate (Atropinum sulphuricum) is obtained from Folium belladonae as a raw material and the solvent used is ethyl alcohol with a concentration of 90°. A number of extraction opsrations liquid-liquid with organic solvents are applied in the purification phase. But the yields are low and the finished product contains atropine and hyosoyamine.

From an economic standpoint the mission considers it necessary to use radix belladonnae, which has a double concentration in active principles as compared with folium belladonnae, and the extraction solvent in the initial phase should be a cheaper one, for example benzone instead of ethyl alcohol.

At the same time, the use of another technological process giving higher yields was recomended during the discussions held. Laboratory tests for finalizing the process must first be carried out, then other measures are recommended in order to obtain a supply of solvents.

The application of an improved technology is possible in the existing pilot plant, but some changes and more equipment costing approximately $US 1,000 (annex III) are necessary.

The mission considers that by developing a new tschnological process or applying the one recommended and by installing new equipment, sufficient quantities of atropine sulphate can be produced to cover the requirements of the developing medicinal industry in Nepal. Moreover, it is necessary to supply the institute with reactants, reference substances and solvents for performing tests and demonstrations. The substances, quantities and indicative prices are given in annex III.

Import substitution

The possibility of substituting some currently imported raw materials, finished products or active principles by similar local products should be

oonsidered. The mission examined the Therapeutio Index for 1975, whioh was drawn up by Royal Drug Ltd, Nepal. Various substitution possibilities are noted below:

(a) For the preparation of Cufnas and Vasaka antiooughing syrups an imported extract of the adhatoda vasioa speoies (aoathaoeae family) is used. During the mission the experts visited the mountainous region in Makwanpur district where this speoies was found in suffioient quantities;

(b) For the preparation of ephedrine hydroohloride (tablets), ephotin (syrup) and nosola the synthetio ephedrine hydroohloride is imported. This speoies oould be replaoed by the indigeneous species Ephedra gerardiana, whioh acoording to the information obtained is found in large quantities in the spontaneous flora. In order to make the best use of this species, phyto-chemical and pharmacological studies will be neoessary;

(c) The imported essential oils neoessary for the preparation of Cufnas, Dentaik, Menoam, Nosola, R.D. Grippe Mixture and Tongil oould be replaced by essential oils obtained from indegeneous herbs.

(d) There is a possibility of preparing some new medioaments from indigeneous herbs by primary prooessing (spraying, tableting eto.), without the need of important investments. Thus the mission reoommends the prepara-tion of some polyvitamin drugs from the perioarp of Rosa sp. fruits and from the dry extraot of yeast, a seoondary product in the produotion of indigenous beer, or from other vitamin-rioh herbs.

Medioinal herbal farms

There are experimental farms for medioinal herbal orops in Nepal. These farms are oo-ordinated by the Department of Medicinal Herbs. The members of the mission visited the following farms:

(a) Brindavan herbal farm, located at about 500 ft altitude with a tropioal olimate;

(b) Tistung herbal farm, looated at about 6,000 ft altitude;

(c) Daman herbal farm, looated at about 8,000 ft altitude.

The last two farms grow subtropioal herbs at high altitudes. The following findings emerged from diaoussions held with researoh speoialists on the farms and the personal on-site investigation of the experts.

Brindavan herbal farm

The Brindavan herbal farm has a surfaoe over 25 ha where oymbopogon oitratus (a looal speoies with a high limonen oonten, oymbopogon winterianus and oymbopogon martini are grown. The oultivated area is to be extended to 100 ha. Taking into aooount the irrigation souroe and the existanoe of a distillation pilot plant for essential oils, the growing of herbal plants

oontaining oitral, limonen and menthol is advisable at this farm. The farm is also suitable for growing ergot of rye. The rioh morning dew may oontribute to the suooess of artioial inooulations and to the seoondary infeotion. Moreover the soil is adequate for the meohanization of the inooulation prooess.

It is also neoessary to maintain herbal plants suoh as rauwolfia serpentina, species and varieties of Mentha (with possibilities of extention), Vinoa rosea, Ocimum kilimandshariour, Hibisous umbrata and Anetum graveoleus on smaller plots.

With regard to personnel, it is neoessary to hire an agronomioal engineer and a ohemist or pharmaoeutioal ohemist or analyst for the essential laboratory oils.

The present pilot plant for the distillation of essential oils uses a teohnology that oan be improved both as to yield and to produot quality, if oertain changes are made and equipment purohases oosting approximately $US 27,825 are made (annex III).

In oase the oultivated surfaoe is extended to 100 ha, the oapaoity of the pilot plant should be enlarged and the equipment and materials listed in annex III aoquired.

Tistung herbal farm

The Tistung farm grows pyrethrum oinerarie folium, Digitalis purpurea, Digitalis lanatha, Atropa balladonna, Diosoorea deltoidea, Mentah piperita, Valeriana offioinalis, Humulus lupulus, Lobelia pyramidalis eto.

Experiements have also been made on growing ergot of rye, but weather oonditions, espeoially the low humidity, do not favour mushroom oultivation. The experts held disoussions with farm speoialists and suggestions regarding the possibility of growing ergot of rye by artifioial infeotions were made.

Daman herbal farm

The Daman farm is an experimental station suitable for growing medioinal herbs at high altitude. An attempt is being made to grow pyrethrum on a large surfaoe of 6.4 ha. Another plot is set aside for growing Aoonitum ferox, a speoies that is frequently found in the spontaneous flora. An effort is also being made to oultivate aoorus oalamus and athropa belladonnae.

The visits paid to the above-mentioned farms led the experts to the conclusion that it would be useful, on the one hand, to extend the present system of crops in terraces with slopes of 45° by growing a larger range of species containing essential oils or other active principles (Solanaceae), thus making it possible better to exploit the soil in the forest perimeter, and on the other hand, to grow species that fix the soil (hippophae, rhamnoides, Rosa sp.) or other species that may be identified by local specialists or international experts. Soil fixation species are recommended for the Tistung and Daman farms or for other similar farms. Such species may have a dual role as both soil fixation agents and raw materials for the manufacture of useful pharmaceuticals.

Physic Garden of the Royal Botanical Gardens, Godawari

The Physic Garden of the Royal Botanical Gardens has a rich collection of medicinal herbs of important therapeutic interest, such as Acorus calamus, Ammi majus, Athropa belladonna, Digitalis purpurea and D. lanatha, Datura sp., Mentha sp., Rauwolfia serpentina, some promising species such as Berberis aristata, Dioscorea Belophylla, Ephedra gerardiana, Podophyllum hexandrum, Solanum Khasianum, Valeriana hardwickii, V. waliichii etc.

The introduction of new species in this garden, besides the scientific value of this living museum of medicinal herbs, may contribute to caryological researches (the botanical garden has also such a laboratory) as an experimental plot of selecting valuable biotypes.

There are plans to transfer the Herbarium of the Royal Drug Research Laboratory to this garden. The Herbarium contains a valuable collection of about 4,000 species, of which a large number are medicinal herbs.

Royal Drugs Ltd

Royal Drugs Ltd is the only medicinal factory in Nepal. It produces medicines from imported raw materials.

According to the Therapeutic Index, the following main groups of medicaments are produced: analgesics, antipyretics, antibiotics, antituberculars, sulpha drugs, hypnotics, sedatives and medicines for external use. In the formulation of some of these medicaments there are active principles which are also imported.

This medicinal factory is in process of extension, the buildings are under construction, and the start-up is expected in 1978. In discussions with the experts the General Manager expressed interest in the extension of the range of products based on medicinal herbs, especially on Rauwolfia, Dioscorea, Belladonna, Athatoda vasica, Veratrum and others.

CONCLUSIONS AND RECOMMENDATIONS

A. Afghanistan

Conclusions

1. The studies made available to the experts (see annex I) and the information gathered during the mission do not comprehensively refer to the following important matters:

(a) Quantitative assessments of the medicinal herbs which could be harvested and collected in the main floral basins, taking into account the ecological implications;

(b) Qualitative evaluation of the active principles contained in the respective medicinal herbs.

A realistic programme for the setting up of a pharmaceutical and/or essential oil industry could not be elaborated without a technical study of the above-mentioned matters. It is necessary to conduct a survey within the framework of an adequately-equipped mobile unit with a sufficient number of experts. The main objectives of such a mobile unit would consist in demonstrations concerning the technical methodology for an economic assessment of natural resources in medicinal herbs and for obtaining essential oils, tanins and alkaloids.

2. There is no processing or conditioning unit for medicinal herbs in Afghanistan.

3. No reliable figures are available concerning the export of medicinal herbs (quantities and assortments). An indicative list, however, is given in annex II.

4. Medium-skilled labour is available, but here is a need for training in medicinal herbs processing. This training could be organized locally.

5. Training programmes for skilled personnel should be organized abroad.

Recommendations

1. The Afghanistan Seven-Year Plan (1976-1982) forsees an export increase of medicinal herbs of from 14,000 t/y to 20,000 t/y, or from $US 7 million to $US 10 million in the last year of the plan. Three groups of medicinal herbs are mentioned: liocrice roots (Glycyrrhiza glabra), medicinal roots and Asa foetida. Taking into account the interest in exporting medicinal herbs mentioned in the plan and expressed during discussions with the experts,

partioularly at the Ministry of Public Health, the Institute of Public Health, the Faculty of Pharmacy and the Ministry of Commerce, it is recommended that the implementation of the UNIDO programme should be continued in its second phase by sending a mobile unit provided with adequate laboratory equipment and a team of experts.

2. The activity of the proposed mobile unit should be focussed on essential oils, tanins, tinctures and alkaloids, because in a first stage these products could be processed in small-scale pharmaceutical units based on technologies which are not highly sophisticated.

3. The best time for the departure of the mobile unit is April-June in view of the required tests, evaluation and demonstrations and of the flora development.

4. At present, the collection of plants is ensured by small dealers who send their agents to collect the herbs from the rural population. This system is not reliable for setting up of a small-scale industry, and it could also lead to the disappearance of valuable species. It is therefore recommended that the local authorities should give priority to the organization of a type of corporation or association of farmers to guide and control medicinal herbs exploitation. Otherwise the Ministry of Commerce would assume this responsibility.

5. In order to acquire the necessary knowledge of medicinal herbs processing, it is recommended that a training programme should be organized at specialized institutes and plants abroad with UNIDO assistance. With regard to the training of local technicians, a programme of demonstrations could be carried out as part of the activities of the mobile unit.

6. With a view to future co-operation, a copy of the final report of an expert mission sent by India to Afghanistan in 1976 to carry out some work on the main medicinal herbs should be made available to UNIDO.

B. Nepal

Conclusions

1. There is a need for economic mapping of some species of spontaneous flora in order to establish their exploitation zone, bearing in mind ecological aspects and the content of the active principles.

2. International assistance is needed to improve the methodology of obtaining and controlling essential oils from herb crops, and to extract essential oils from medicinal herbs which are widely spread in the spontaneous flora. In particular, the application of a new technological process or the installation of new equipment would make it possible to produce sufficient quantities of atropine sulphate to cover the requirements of the medicinal industry in Nepal.

3. Various possibilities exist for the substitution of certain imported raw materials, finished products or active principles by similar local products.

4. It would be useful at the herbal farms to grow species which fix the soil and to extend the system of crops in terraces with 45° slopes by growing a wider range of species containing essential oils or other active principles.

Recommendations

1. Taking into account the state of production of medicinal plants as raw materials for the pharmaceutical industry in Nepal, urgent assistance should be provided during the current year in the form of experts, equipment and chemicals.

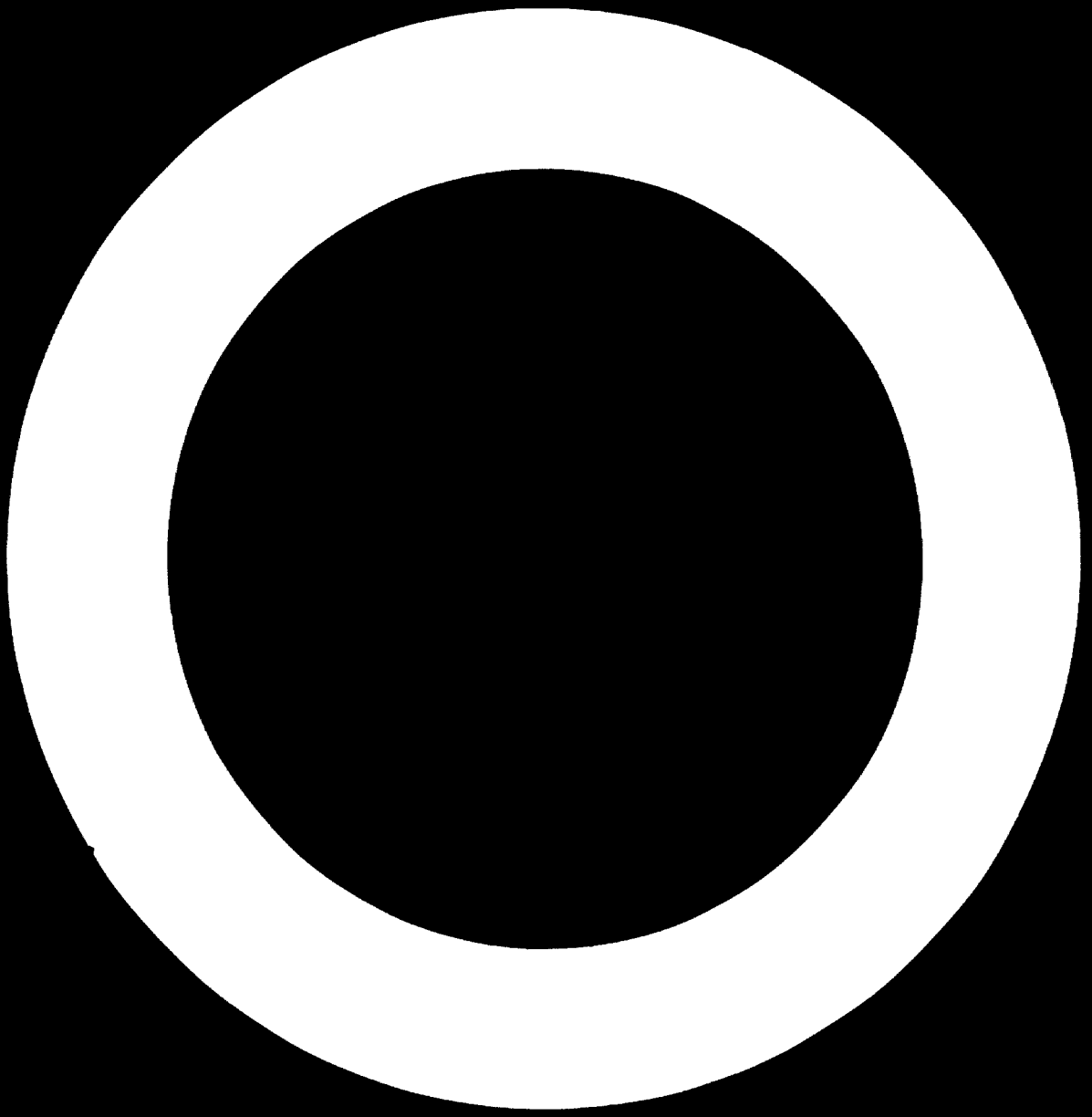
2. In the first stage of an assistance programme, two experts, a botanist/agronomist and a technologist in destillation and extraction, should be sent to Nepal to deal with the following matters:

(a) Methodological demonstrations on site with a view to drawing up economic maps of medicinal herbs, including quantitative and qualitative determinations of active principles. For this purpose is will be necessary to supply the equipment and materials listed in annex III;

(b) Laboratory assistance in obtaining the necessary multiplication material (mycelium and conidia of Claviceps purpurea) for artificial inoculation in the production of ergot of rye with a high content of alkaloids. This will require the provision of the substances and apparatus listed in annex III;

(c) Assistance in the improvement of the technology applied in atropine extraction at the pilot plant of the Royal Drugs Laboratory. With this aim in view it is necessary to provide the substances and solvents listed in annex III;

(d) Laboratory assistance for testing alkaloids and essential oils and the technologies to be applied at the pilot plant. The application of these improved technologies for the extraction of essential oils requires supplementary equipment at the existing pilot plant at Brindavan Herbal Farm. Annex III contains lists of the equipment required, on the one hand, to permit the processing of fresh herbal crops (about 300 t/y) harvested from the actual cultivated area of 25 ha, and, on the other hand, to increase the capacity of the existing pilot plant to 1,500 t/y of fresh crops, to be harvested following the planned extension of the cultivated area to 100 ha.



Annex I

DOCUMENTATION

A. Afghanistan

Afghanistan Hortioultural Subseotor Survey. Projeoted oommeroial exports during the seven-year plan (1976-1982).

Lakobos, A. and S.A. Ghanzafar. Feasability study on the establishment and development of pharmaceutioal industry in Afghanistan. Kabul, 1976.

I.T.E.C. Experts on medioinal herbs from India. 1976. Preliminary report.

Pelt, J.M., J.C. Hayos and M.Ch. Younus. Plantes medioinales et drogues de l'Afghanistan. Bulletin de la Sooiété de Pharmaoie de Nanoy, 66, September 1965.

Roshan, M. Reshad. Contribution à l'étude des plantes medioinales de l'Afghanistan. Bulletin des travaux de la Sooiété de Pharmaoie de Lyon, 12: 4: 131-142, 1968.

Thomas H. Miner and Assooiates. Developing the herb industry of Afghanistan. Chioago, June 1968.

Younus, M.Ch. List of Afghan medioinal herbs. University of Kabul, faculty of pharmaoy, Maroh 1976.

B. Nepal

The experts were provided by the Royal Drug Researoh Laboratory with the following documentation:

Annual report (1973/74) of H.M.G. of Nepal - Department of Medioinal plants eto.

Therapeutio index 1975 - Royal Drugs Ltd

Royal botanioal garden - Godawary (Guide)

Notes on flora of Rajnikunj

Flora of Phulohoki and Godawari

Flora of Nagarjun

Suplement to the flora of Phulohoki and Godawari

Key to the Dicotyledonous Genera in Nepal, Part I and II

Annex II

AFGHAN MEDICINAL PLANTS EXPORTS AND PRODUCTION

Table 1. Export of medicinal herbs in 1974

Importing country	Commodity	Quantity (kg)	Value	
			AF	$
Pakistan	Coriander seeds	952,784	14,094,437	239,592
	Aniseeds	31,441	884,373	14,941
	Caraway seeds (white)	2,124	11,987,174	198,340
	Caraway seeds (black)	316,237	18,956,125	332,549
	Caraway seeds (kajak)	332,132	12,463,684	160,160
	Other Caraway seeds	31,637	1,171,307	19,926
	Poppy seeds	272,695	11,806,825	202,537
	Asafoetida	17,960	1,883,909	32,260
	Gum tragacinth (Tragacantha)	581	6,343	109
	Ajowan	150,349	3,131,359	53,021
	Hyssop	1,099	17,176	290
	Liquorice	1,626,716	31,559,354	535,298
	Jujub	98,760	2,218,522	37,820
	Other medicinal herbs	102,730	2,526,658	42,061
	Gum powder	35,293	375,808	6,281
France	Aniseeds	4	61	1
	Caraway seeds	11	363	6
	Liquorice	50,022	1,204,942	20,009
	Other medicinal herbs	31,740	1,911,383	31,740
India	Caraway seeds (white)	9,324	2,431,539	42,185
	Caraway seeds (black)	5,600	155,075	2,767
	Caraway seeds (kajak)	38,640	2,155,709	37,096
	Other caraway seeds	10,868	1,886,240	32,634
	Asafoetida	125,813	19,683,402	336,460
	Hyssop	7,495	284,038	4,849
	Liquorice	1,083,458	64,862,781	1,101,845
	Jujub	117,609	7,930,811	134,055
	Other medicinal herbs	151,547	4,848,842	82,165
Iran	Caraway seeds (black)	7,020	549,568	9,126
	Other caraway seeds	4,680	457,639	8,040
	Liquorice	40,972	958,265	16,389
	Other medicinal herbs	94,941	3,970,721	67,103
Italy	Poppy seeds	50,000	3,011,000	50,000
	Liquorice	304,225	71,224,649	1,219,388
	Other medicinal herbs	138,465	3,039,738	54,233

a/ Values are calculated on the basis of 1974 conversion rates of the Afghani in relation to the United States dollar, which were approximately Af 56-60 = $US 1.

Table 2. Medioinal plants produotion in 1975

Herbs	Annual produotion (in tons)	Price per ton[a] Af	$	Source
Liquorioe	1000	7,000	125	Mountain
Yarling	1000	10,000	175	Mountain
Stataise limonium	500	15,000	260	Mountain
Centaury (Centaury behen)	5000	25,000	435	Mountain
Drone (Hydrastis ranunoulaoeae)	3-5	15,000	260	Mountain
Cowparanip	4	30,000	520	Mountain
Eghar	3	25,000	435	Mountain
Glue stiok	500	28,000	485	Wild
Dried rose petals	3	50,000	865	Mountain
Berberis	100	8,000	140	Wild
Marshmallow root	4	14,000	245	Mountain
Fennel (Foenioulum volgare)	500	45,000	780	Wild and Cultivated
Ribwort (Planage Major)	10	22,000	380	Mountain
Ajowan (Corum ooptioum)	5	35,000	605	Cultivated
Coriander (Coriander sativan)	10	20,000	350	Cultivated
Poppy (white)	100	18,000	315	Cultivated
Hedde mustard	10	60,000	1,050	Cultivated
Caraway (Jarum oarui)	200	20,000	350	Wild
Asafoetida	50	90,000	1,560	Mountain
Borage (leaf)	3	15,000	260	Mountain
Borage	1	35,000	605	Desert
Pepperment (white)	10	120,000	2,080	Cultivated
Common spearmint	10	80,000	1,390	Desert
Manna (Alhagi persrum)	3	70,000	1,210	Mountin
Warmseed	5	70,000	1,210	Desert
Small Gorden (Nigilla staiva)	10	60,000	1,050	Cultivated
Traigonella foenum (graeoum)	50	20,000	350	Cultivated
Henna (leaf)	200	20,000	350	Mountain and desert
Harmall (peganum hermala)	5	10,000	175	Mountain and desert
Meadow suffrun, Coloioum autumnale	5	70,000	1,210	Desert
Jawani khorasani (Fondona)	3	45,000	780	Desert
Punioa granatum (pomegranate)	5	30,000	520	Mountain
Zok	5	25,000	435	Mountain
Turk dorna	2	45,000	780	Mountain

a/ Values are oalculated on the basis of 1975 oonversion rates of the Afghani in relation to the United States dollar, whioh were approximately Af 57 = $US 1.

Annex III

MEDICINAL PLANTS PRODUCTION REQUIREMENTS IN NEPAL

A. Materials, reagents and equipment required for obtaining ergot or rye

Laboratory stage

Test tube 200 mm x 20 mm	200	
Pyrex flask, 4 l	2	
Glass funnel and stand, diam. 20 cm	2	
Rubber tubing, diam. 1 cm	4	
Kalium phosphate monobasic	15	g
Magnesium sulphuricum	15	g
Asparaginum	150	g
White pepton	20	g
Gluoosum pur.	150	g
Maltosum pur. Merok	150	g
Extr. Maltz sicc.	150	g
Agar-agarum (in filis Jap.)	500	g
Non degreased wadding	500	g
Ethyl alcohol, 96°	2	l
Corrosive sublimate	20	g
Quartz lamp	2	
U.V. luminescence tube	2	
Bunsen burner	2	
Pincers	2	
Lancets	2	
Loops	5	
Paper filters	5	sheets
Petri dishes	10	
Standard substances (ergot alkaloids)	5	g
Test paper Merok (pH)	2	boxes

Estimate cost: $477

Thin-layer chromatography

Quickfit catalogue, set 8CR

Plate 20 cm x 20 cm	5
Plate 20 cm x 10 cm	5

Estimated cost: $600

Fluotest type "Universal Hanau" (catalogue No. 5201)

Plus: 4 Strahler, 6 Watt (366)
15 Strahler, 15 Watt (254 mm)

Estimated cost: $790

Innoculation of rye on site

Innoculation apparatus	4
Filtering sieve (stainless) diam. 50 cm	2
Plastic pail	4
Gauze	10 m^2

Estimated cost: $80

Total estimates cost: $1,947

B. Substances and solvents required for improving the technology of obtaining atropine and essential oils

Pure sulphuric acid: 3 kg
Ammonia 25%: 6 kg
Chloroform: 15 kg
Ethyl ether P.A.: 25 kg
Potash sicc.: 1 kg
Benzene: 10 kg
Pure sodium hydroxide: 3 kg
Sodium sulphate sicc.: 10 kg
Acetone: 10 kg

Estimated cost: $200

Glass extraction columns

4 extraction columns: 200 mm x 1000 mm, 5 - 8 mm thickness

2 joint columns with 3 glass valves and flanges

Estimated cost: $800

Total estimated cost: $1,000

C. Supplementary equipment required at the Brindavan herbal farm pilot plant

Table 3. Requirements for processing 300 t/y of fresh herbal crops

Case 1: stainless steel equipment and electric heating

(flowsheet No. 1)

Flow sheet position	Equipment	Pieces	Material	Weight (kg)	Estimated cost ($)
1	Extraction-distilling apparatus Cylindrical reactor, vertical with agitator, electic heating in the outer jacket V = 1000 l n = 30 rpm N_1 = 4.5 kW for agitator N_2 = 50 kW for heating	1	stainless steel	1,800	11,000
2	Heat-exchanger tube sheet[a] Surface: 4 m^2 Water cooling Size: 300 mm x 300 mm x 1500 mm	1	Stainless steel	400	4,300 Could be cancelled by using existing heat exchanger)
3	Cylindrical and vertical receiver vessel[a] V = 100 l Size: 500 mm x 500 mm x 850 mm	1	Stainless steel	100	1,700
4	Centrifugal pump for water supply Q = 2000 m^3/h; H = 20 m water gauge n = 1500 rpm; N = 2.8 kW Size: 650 mm x 450 mm x 850 mm	1	Steel	250	530
5	Blowing fan-feeder conveyer Q = 2000 m^3 P = 600 mm water gauge N = 2.8 kW; n = 1500 rpm Size: 500 mm x 500 mm x 600 mm	1	Steel	200	530

6	Plant cutter Feed chute for herbs, cutting baskets with helical conveyer, sizer, down-tank N = 5 kW Size: 1000 mm x 1000 mm x 800 mm	1	Steel	300	670
			Totals	3,100	18,730

a/ Position 2 and 3 could be locally finance and filled.

Total cost estimate		$
Equipment		18,730
Steel construction supporting the equipment		2,340
Insulation (conducts, equipment etc.)		1,330
Conducts, fittings:	10 m stainless steel conducts 30 m steel conducts 5 stainless steel valves 5 steel valves 50 flanges	4,650
	Total	27,050
Transport: European port, Nepal $250/t x 3.1 t		775
	Total costs	27,825

Case 2. Enamel equipment and external wood or other fuel heating source (flow sheet No. 2)

Flow sheet position	Equipment	Pieces	Material	Weight (kg)	Estimated cost ($)
1	Heating source Cylindrical and vertical furnace boiler with wood fireplace Size: 1000 mm x 1000 mm x 1000 mm	1	Steel; fire resistant bricks	1,000	670
2	Ciruclating pump for heat carrier a/ Q = 5m^3/h; H = 12 m water gauge n = 1500 rpm; N = 2.2 kW Size: 650 mm x 450 mm x 850 mm	1	Steel	250	530

3	Extraction-distilling apparatus[a/] Vertical and cylindrical reactor with agitator and turnover system V = 1000 l n = 30 rpm; N = 4.5 kW Size: 1000 mm x 1000 mm 3200 mm	1	Enamel steel	2,100	11,300
4	Heat exchanger with double cooling jacket Surface: 4 m^2 Water cooling Size: 800 mm x 800 mm x 1700 mm	1	Enamel steel	1,200	4,650
5	Cylindrical and vertical receiver vessel V = 100 l Size: 500 mm x 500 mm 750 mm	1	Enamel steel	250	1,670
6	Centrifugal pump for water supply Q = 5 m^3/h; H = 200 m water gauge n = 1500 rpm; N = 2.8 kW Size: 650 mm x 450 mm x 850 mm	1	Steel	250	530
7	Plant cutter Feed chute for herbs, cutting basket with helical conveyer, sizer, down-tank N = 5 kW Size: 1000 mm x 1000 mm x 800 mm	1	Steel	200	670
8	Blowing fan-feeder Q = 2000 m^3/h p = 600 mm water gauge N = 2.8 kW n = 1500 rpm Size: 500 mm x 500 mm x 600 mm	1	Steel	200	530
	Totals			5,500	20,550

a/ Position 2 and 3 could be locally financed and executed on site.

Total cost estimate		Cost (in $)
Equipment		20,550
Steel construction supporting the equipment (approximately 5 t)		2,340
Insulation (conduots, equipment)		1,330
Conduots and fittings:	10 m enamel conduots 5 enamel valves 5 steel valves 30 m steel conduots 50 flanges	6,700
	Total	30,920
Transport: European port, Nepal $250/t x 5.5 t		1,380
	Total costs	32,300

Requirements for processing 1,500 t/y of fresh herbal crops

For processing 1,500 t/y of fresh herbal crops an extraction-distilling apparatus with the following features should be added to the equipment listed in table 3, case 1.

V = 3000 l

n = 30 rpm

N = 5.5 kW

Estimated cost: $15,400

The equipment cost will in this case become about $34,150

Estimated thermal energy

Heating energy: $Q_1 = mc\,\Delta T = 1000 \times 1 \times (100^{\circ}-20^{\circ}) =$ 80,000 kcal

Boiling energy: $Q_2 = m\lambda = 1000 \times 540 =$ 540,000 kcal

Total energy/charge = 620,000 kcal

1 charge = 3 hours

Heating rate: $Q = \frac{620{,}000 \text{ kcal/charge}}{3 \text{ hours}} = 206{,}000$ kcal

Case 1: electric heating $\frac{206,000 \text{ kcal/h}}{860 \text{ kcal/kWh}} = 240 \text{ kW}$

For 1 charge: 3 h x 240 kW = 720 kWh/charge

Case 2: wood or fuel for heating

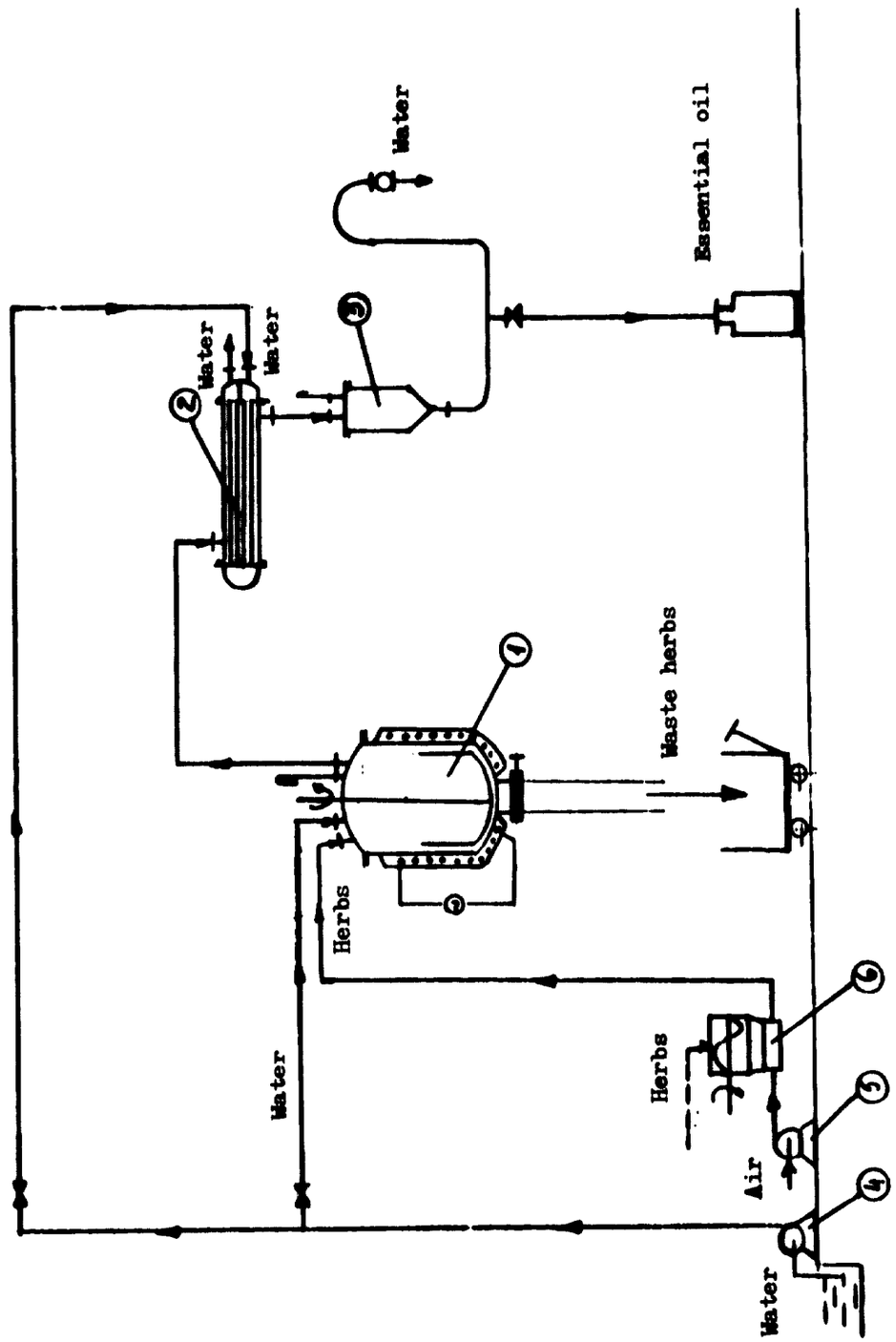
Q = mq, where q = 2800 kcal/kg, wood-fuel calorific value

$m = \frac{206,000}{2800} = 73$ kg wood-fuel/h

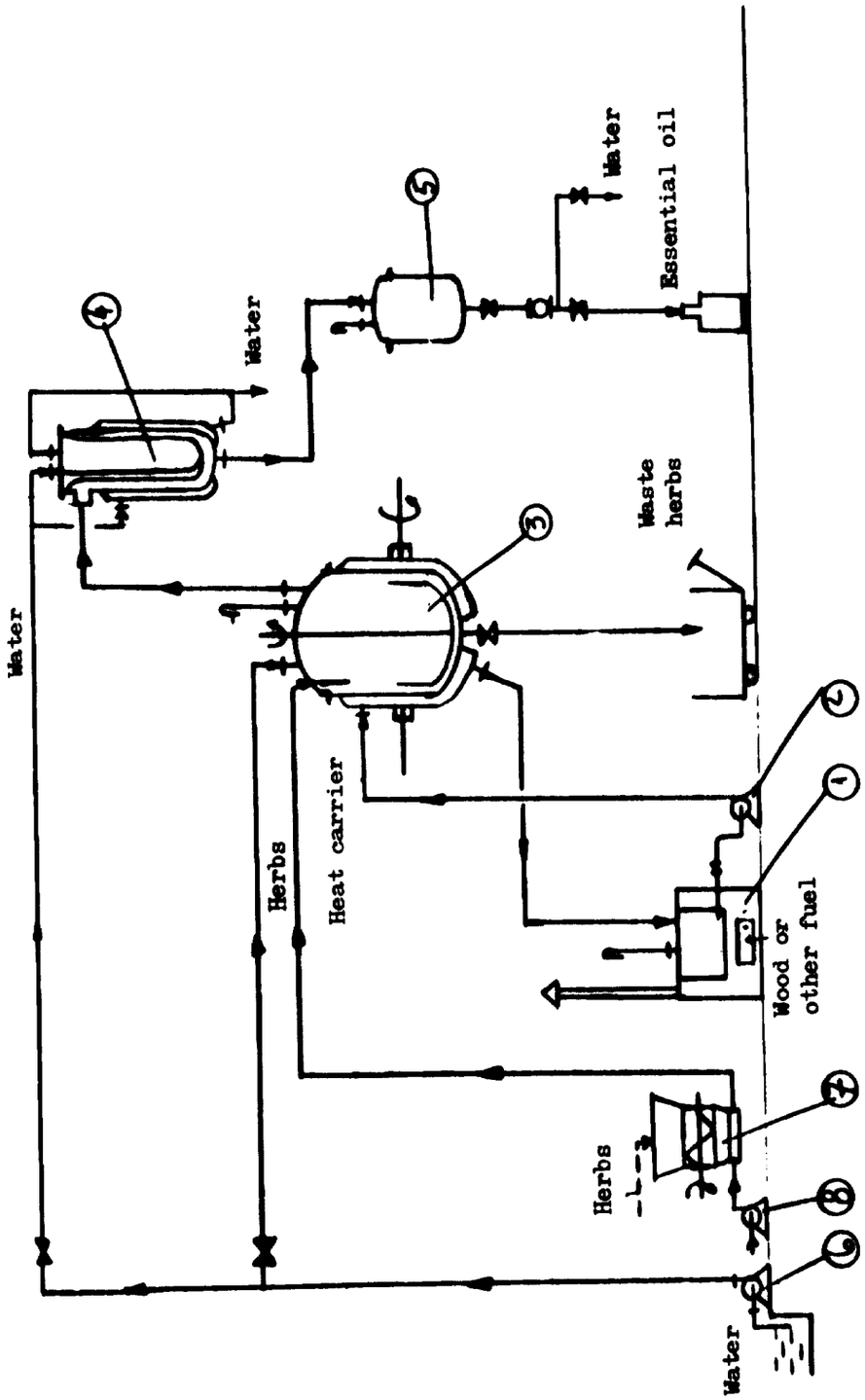
For 1 charge: 3 h x 73 kg/h = 219 kg wood-fuel/charge

D. Equipment and materials required for methodological demonstrations in Nepal

Equipment and materials	Cost (in $)
Cross-country vehicle or a micro-bus with double traction Fuel, lubricants, tyres and spare parts	6,000
Analysis kit for volatile oils, alkaloids, glycosides and tanins	40
Compass (1), altimeter (1), maps	47
Two isothermic tents, each for two persons	400
Protection equipment (overalls, boots etc.)	200
Two presses for herbarium	5
First-aid kit	10
Portable gas-burner with four gas cylinders	47
Plates and dishes, canned food for 30 days (three stages of ten days each)	100
Total estimated cost	6,849



Flow sheet 1. Essential oils plant flow sheet for stainless steel equipment and electric heating



Flow sheet 2. Essential oils plant flow sheet on enamel equipment and external heat source (wood and other fuel)

Annex IV

ANALYSIS BULLETINS

Product

Oleum Citronellae - Source: Nepal, February 1977

Description

Yellow liquid, having a strong penetrating characteristic odour

Solubility in alcohol

1 vol. of Citronella oil in 2 vol. of alcohol 80%: it is colourless; 1 vol. of Citronella oil in 10 vol. of alcohol 80%: it is opalescent

Fractional distillation

	Fractions		
I.	(160°C-199°C)	= 2.5%	- colourless
II.	(200°C-210°C)	= 12.5%	- colourless
III.	(211°C-215°C)	= 40.0%	- pale, yellow
IV.	(216°C-230°C)	= 30.0%	- yellow

Distillation traces or residues

15%

Specific gravity

Unrectified oil = 0.914 at 20°C
Fraction I = 0.902 at 20°C
Fraction II = 0.905 at 20°C
Fraction III = 0.912 at 20°C
Fraction IV = 0.913 at 20°C

Angular rotation (α^{21}_{D})

Fraction I = -11.9
Fraction II = -12.6
Fraction III = -14
Fraction IV = -16.1
Raw oil = -16.5

Refractive index

Fraction I = 1.460
Fraction II = 1.4605
Fraction III = 1.461
Fraction IV = 1.468
Unrectified = 1.468

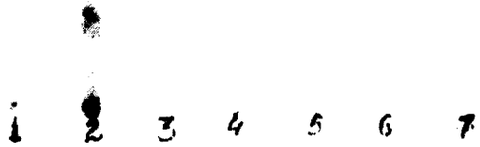
Total geraniol in Fraction II = 51.3%

Thin-layer chromatography characterization: see exhibit 1.
Gas chromatography characterization: see exhibits 2 and 3.

Conclusions

Fractional distillation was used to obtain an essential oil with high parameters from the tested sample. Fractions I to IV representing 85% of the raw product meet the quality parameters.

Exhibit 1
(Oleum Citronellae)



1 Unrectified Citronella oil
2 Fraction I
3 Fraction II
4 Fraction III
5 Fraction IV
6 Boneol
7 Geraniol

Exhibit 2

(Oleum Citronellae)

Gas chromatography characterization

Fraction III

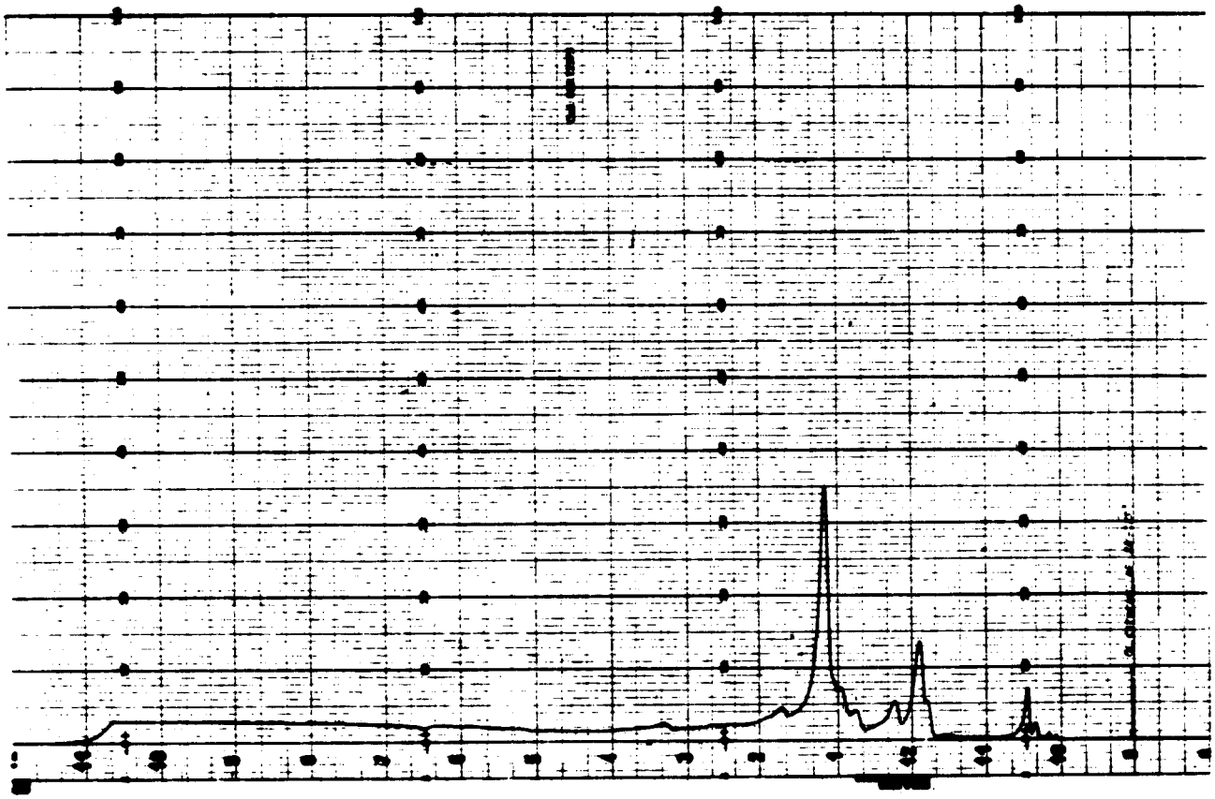
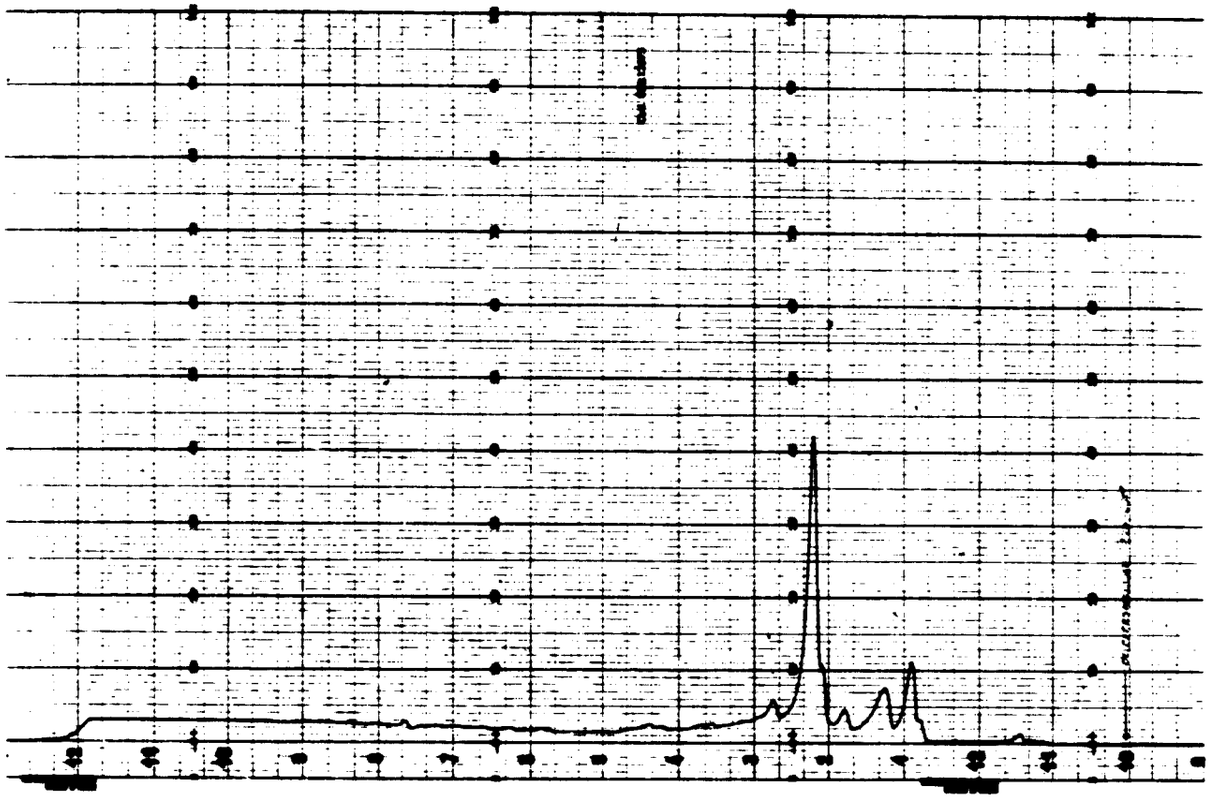


Exhibit 3

(Oleum Citronellae)

Gas chromatography characterization

Fraction IV



Product

Oleum Menthae (mint oil) - Source: Nepal, February 1977

Description

Pale yellow liquid, having a strong penetrating odour of menthol and a pungent taste, followed by a sensation of cold when air is drawn into the mouth

Solubility in alcohol

1 vol. of mint oil in 4 vol. of alcohol 70%

Specific gravity

0.908 at 20°C

Angular rotation

$(\alpha\ ^{21}_{D})$ -39.5 in a 100 mm tube at 21°C

Refractive index

1.460

Total menthol

70.8%

Esterified menthol

15%

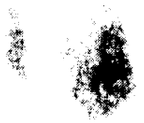
Thin-layer chromatography characterization: see exhibit 4.
Gas chromatography characterization: see exhibit 5.

Conclusions

The tested sample is characterized by a high content of total oleum menthae, but probably due to conservation, approximately 20% of it is esterified menthol.

This situation can be avoided by protective measures during or after distillation.

Exhibit 4
(Oleum Menthae)



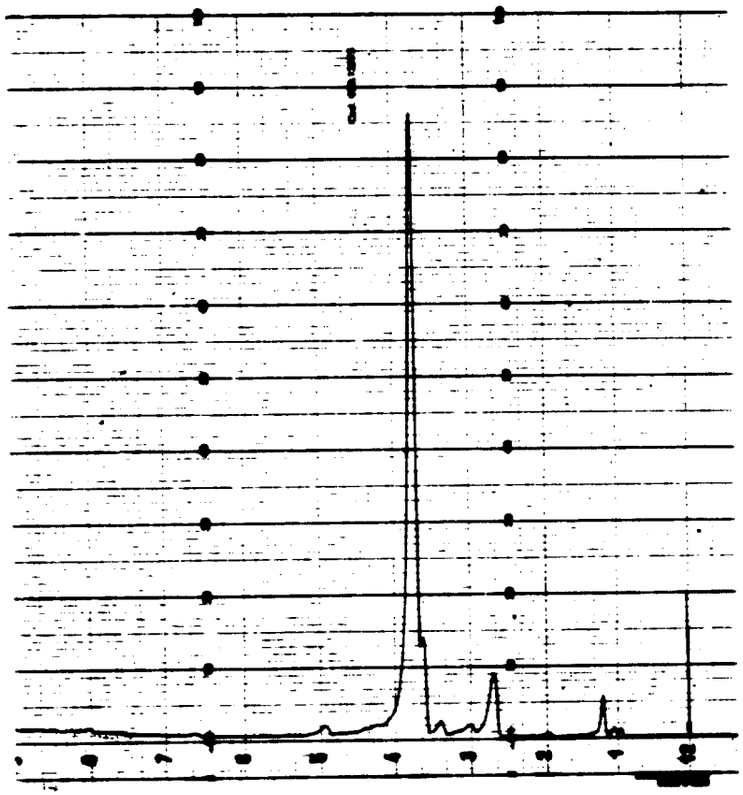
1 2 3 4 5

1 Pure Menthol
2–4 Mint oil samples
5 Pure Menthol

Exhibit 5

(Oleum Menthae)

Gas ohromatography characterization



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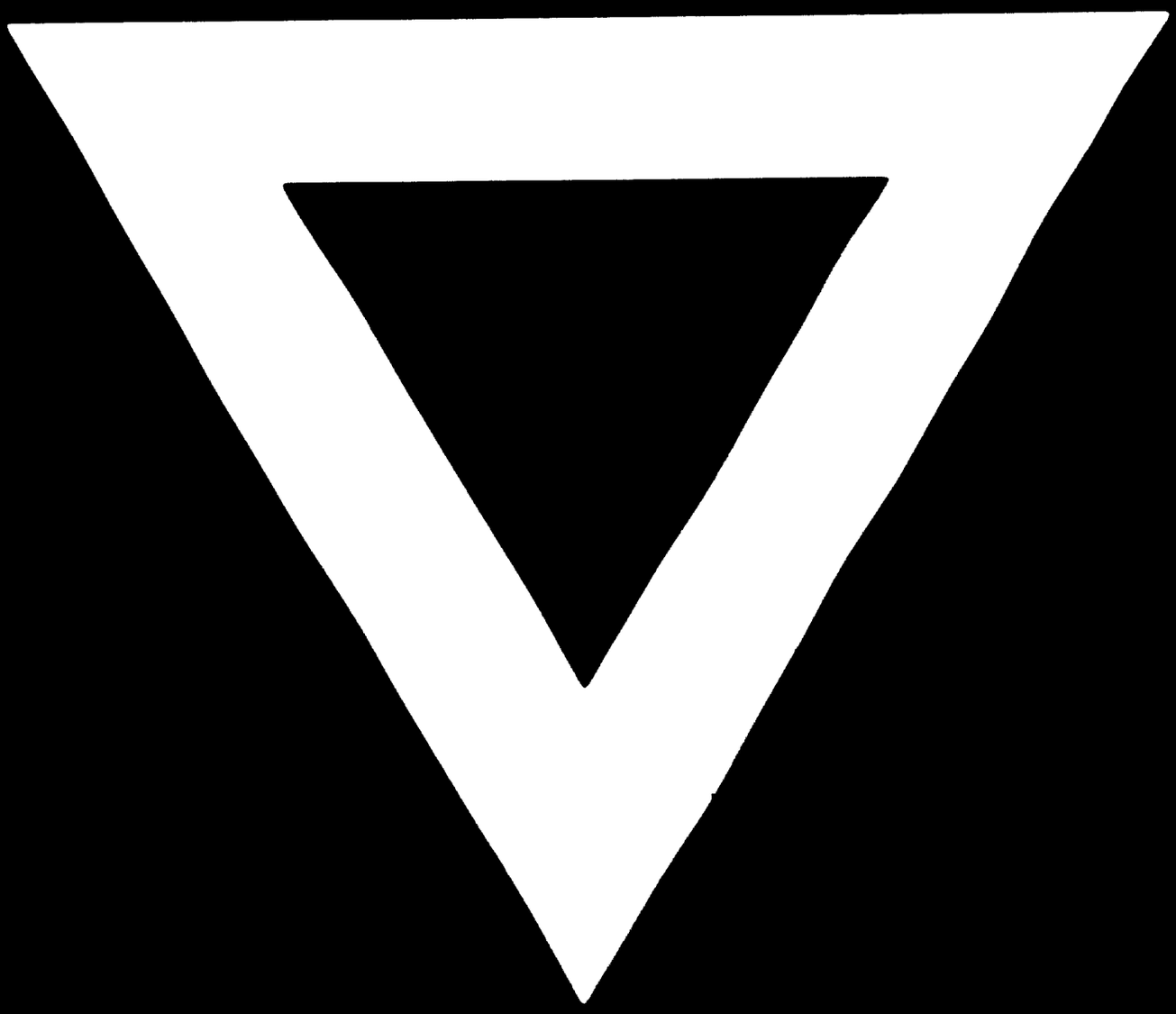

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