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Workshop on Industrial Utilization of
Medicinal Plants
Beijing, China
15-23 October 1990

REPORT*

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CONTENTS

INTRODUCTION

The Workshop on Industrial Utilization of Medicinal Plants was held in Beijing, China from 15-23 October 1990. It was sponsored by UNIDO and hosted by the State Pharmaceutical Administration of China (SPAC). For UNIDO the workshop was a continuation of a number of activities supporting technical assistance programmes on the development of the industrial use of medicinal raw materials derived from vegetable and animal sources. In particular the recent System of Consultations "Interregional Meeting for Co-operation among Developing Countries on the Development of the Pharmaceutical Industry" (New Delhi, India, 19-22 March 1990) recommended that industrial drug policy should include development of plant-derived medicines and ancillary industries. As proposed by the recommendations and action programme of that meeting, the Workshop contributed to strengthening regional and international co-operation between countries from different geographical regions by assisting in identifying specific project areas where Chinese and their counterpart institutions and manufacturing enterprises could co-operate technically and economically. It also considered establishment of national information data bases and regional and subregional information networks that could collect, manage and disseminate information in medicinal and aromatic plants and plant-derived preparations, taking into account the needs of potential users, including those involved in R and D, training, decision-making and production.

The Workshop was also a further step in the ongoing UNIDO programme offered to industrialists seeking to initiate or expand their long-term co-operation with counterparts in other developing countries.

The purpose of the meeting was to develop closer co-operation between China and other developing countries in the field of pharmaceutical production. Identification of areas of industrial co-operation both prior to and during the meeting enabled extensive bilateral discussions among the participants. The discussions took place in the context of an exhibition and audio-visual display by Chinese plant-based medicine institutions and a study tour with visits to a hospital, R and D institutions and manufacturing enterprises in Beijing, Tianjin and Shanghai.

I. ORGANIZATION OF THE MEETING

The meeting was attended by 56 participants, 18 from 11 countries outside China. The list of participants is attached as Annex VI.

Opening of the meeting

The workshop was opened by the Vice-Minister and Director-General of SPAC, Mr. Qi Mou Jia. Further welcoming remarks were addressed to the meeting by Deputy Director of the Department of International Relations of the Ministry of Foreign Economic Relations and Trade (MOFERT), Mr. Zhang Guo Quan and the Chief of the Section for Economic Co-operation among Developing Countries on behalf of the Director-General of UNIDO, Mr. Domingo Siazon.

Inaugurating the meeting, the Vice-Minister underlined China's wish to share her experience in developing the industrial utilization of medicinal plants with the Third World countries. This could involve contributions in areas of R and D on medicinal plant resources, production technology and equipment, engineering design, and provision of experts and training.

Election of officers

Prof. Jin Yunhua (Yunhua Kim), Executive Vice-Chairman of the Committee on Technology, State Pharmaceutical Administration of China (SPAC) was elected Chairman and Dr. Amarillis Saravia, National Co-ordinator and President of CONAPLAMED, Guatemala, as Vice-Chairman. Prof. C.O.N. Wambebe, Director and Chief Executive, National Institute for Pharmaceutical Research and Development, Nigeria, was elected Rapporteur.

Adoption of the agenda

The meeting adopted the following agenda:

- Opening of the meeting
- Election of the Chairman, Vice-Chairman and Rapporteur
- Adoption of the agenda
- Presentation of host country papers
- Presentation of UNIDO paper
- Presentation of national papers
- Bilateral discussions on co-operation projects
- Discussion and adoption of draft conclusions and recommendations
- Closure of the meeting

The work programme is attached as Annex I. Formal papers presented or made available for this meeting are listed in Annex VI.

Adoption of conclusions and recommendations

The meeting adopted the draft conclusions and recommendations at its last session on 20 October 1990.

Closure of the meeting

Reviewing the event's activities, the Chairman said the meeting would both promote South-South co-operation and ultimately benefit the health of people in the developing countries. The UNIDO workshop had been timely and necessary. The fact that scientists, industrialists, experts and administrators had got to know one another better, paved the way for setting up - with UNIDO guidance - a regional centre for information, development and training. Co-operation agreements had been signed in the areas of surveying and assessing natural resources, breeding, propagation and cell engineering, R and D on products and dosage forms, diagnoses of production units requiring rehabilitation, design and engineering, and training.

The Chief of the UNIDO Section for Economic Co-operation among Developing Countries thanked the host organization, SPAC, and the other institutions and enterprises that had supported the workshop and the associated study tours. He assured participants that UNIDO would, if requested, continue to provide support for their working agreements within limits of available funds.

On behalf of SPAC and all participants, the Chairman thanked the four UNIDO representatives. She thanked the participants for their co-operation and closed the meeting.

II. SUMMARY OF STATEMENTS DELIVERED AT THE PLENARY SESSION

The Vice-Minister and Director-General of SPAC noted that after the founding of the new China, industrial utilization of medicinal plants had been strongly promoted and significantly developed. This approach would continue to play an important role in China's health care. For the Department of International Relations, MOFERT, its Deputy Director added that the Workshop was the first in the history of co-operation between China and UNIDO. Medicinal herbs were found in many developing countries and were an important source of remedies for a large number of diseases, especially those of a chronic nature. The Workshop would provide an opportunity for academic exchanges with other developing countries, for learning from each other, and for promoting mutual understanding and expediting South-South co-operation.

The head of UNIDO's Section for Economic Co-operation among Developing Countries thanked the Chinese Government, particularly the Ministry of Foreign Economic Relations and Trade, the China International Centre for Economic and Technical Exchanges (CICETE) and SPAC not only for hosting the meeting but also for making UNIDO's part possible with a substantial financial contribution to the UNIDO Industrial Development Fund. He hoped that the Workshop and associated study tours would enable participants to incorporate new technologies and methodologies in their own research, production and marketing strategies and that they would become aware of technical co-operation among developing countries (TCDC) for future initiatives. A UNIDO officer explained TCDC in the context of traditional technical co-operation and of ECDC, adding that ECDC in this field was a part of South-South co-operation recommended by the South Commission in its recent report. Although the primary actors in the follow-up to the working agreements foreseen from the bilateral discussions would remain with the Workshop participants themselves, UNIDO and other United Nations organizations could be requested to assist, he noted. In addition to the familiar funding systems for such support, e.g. UNDP or the Industrial Development Fund, self-financing trust funding--an increasing resource for project beneficiaries--may also be considered.

On behalf of UNIDO's System of Consultations, a UNIDO officer outlined the aims and accomplishments of the three Consultation Meetings devoted to the pharmaceutical sector. At the Third Consultation on the Pharmaceutical Industry in particular (held in Madrid, Spain in October 1987), herbal medicine and drugs derived from medicinal plants were generally recognized as having a vital role to play in health-care programmes of large segments of the world's population. The interregional meeting on co-operation among developing countries for the development of the pharmaceutical industry, held in India in March 1990 had recommended:

- Full utilization of plant-derived medicines, as an important resource in any strategy for developing the pharmaceutical industry;
- R and D aimed at validating traditional remedies using modern scientific techniques and developing methods and standards for assessing quality and stability, developing new medicaments,

upgrading process technology and identifying new chemical structural models for modern drug development;

- o Systematic crop-wise cultivation and genetic improvement of plant resources for use in industrial-scale processing;
- o Establishment of a regular mechanism for ECDC and TCDC in the following fields: information networks and data bases, training of manpower, R and D activities, engineering services, supply of equipment, machinery fabrication, co-operation in production including joint ventures, raw material and chemical trade and marketing arrangements, and exchange of information.

The plenary session also featured five major technical contributions by SPAC and its constituent institutions. These are summarized in chapter III.

III. CHINA'S SUPPLY CAPABILITIES

China's industrial utilization of medicinal plants

The basis for China's co-operation with other countries was her own experience in developing industrial utilization of medicinal plants, especially in the past forty years. This period had seen a rise in the output value of medicinal plant-based medicaments by a factor of 100, bringing them to 25 per cent of the nation's gross industrial output of pharmaceuticals. In Tianjin, one of China's main production centres, plant-derived pharmaceuticals now accounted for one third of overall production of pharmaceuticals. But to reach these levels, there had to have been radical changes in the scale of operations, factory buildings, equipment, dosage forms, technology and management.

At the industry level, China had 1,300 pharmaceutical factories, 36 per cent of her total devoted to manufacturing plant-based medicines. Their output included 176 products (plus 205 derivatives) based on active ingredients extracted from medicinal plants which were made into monomers or modified and screened. Some 45 products (plus 51 derivatives) were synthesized, modified and screened from medicinal plants. Extracts and active ingredients extracted and prepared from single plants found their way into 438 products (plus 333 derivatives). Nearly 600 factories made the 4,500 preparations characterized as Chinese traditional medicines and prepared commercially using traditional processing techniques to make extracts and powders.

Altogether 46 dosage forms were in commercial use, either the modern forms such as tablets, capsules, granules, suppositaries, injections and oral liquids, or the traditional preparations such as honeyed boluses, water paste pills, powders, soft extracts and mineral pellets.

In processing, although preparation powder had tended to give way to extractions and manufacture of extract-powder mixtures, and to manufacture of extract tablets or tablets with powder mixtures, powdering still played an important role because of processing simplicity and lower cost. In a typical production unit, many different plants required for one prescription--a key characteristic of Chinese traditional medicines--were extracted or made into a fine powder directly. Where appropriate, plants were specially treated before extraction or grinding in order to adjust

their properties, e.g. lower toxicity or raise efficacy. New unit operations such as fluidized bed drying and granulation, and programme-controlled non-aerial suspension coating had been introduced.

With modern dosage forms many processing problems had to be overcome, such as tablets sticking to dies and cracking, solid dosage forms that disintegrated before use or which were too hard or showed surface blemishes. Today, virtually all kinds of design and equipment needs could be met from internal resources--from individual specialized machinery items to complete extraction workshops.

Solving problems of resourcing

In China, some 5,000 species of plants were being used for medical purposes. Of the 1,000 in common use, 200 were domesticated; they accounted for 40 per cent of usage and required 350,000 ha of land. Three national surveys of wild resources had been undertaken plus special investigations in key regions and of important species. This data would become available in a book on resources of Chinese medicinal materials now being compiled. Broadly the same approach had been used by Chinese experts in assisting other countries, for example Brazil and Guatemala.

Such surveys were carried out by professionals drawn from different fields--botany, ecology, pharmacy, agriculture, chemistry and forestry. To help them, advanced portable instruments and equipment had been developed, for example for field analysis of phytochemical constituents. Information on geography, climate, soil, vegetation, biological and ecological counts, horizontal and vertical distribution and type of community, was combined with that from ethnobotanical investigations to give a plant utilization pool and a distributional map.

China had developed standardized procedures for determining the identity, purity and quality of medicinal raw materials supplied for industrial use. Identification relied on plant taxonomy combined with microscopic, physical and chemical examinations. Samples were often compared with the cell-, tissue- and powder characteristics of some 380 authentic crude drugs. Ultra violet spectral analysis of ethanol or methanol soluble extracts was also used.

Measures to protect certain species from over-exploitation now included special laws and regulations banning or requiring supervised collection, state-formulated top prices, scientifically stipulated fencing, cultivation and harvesting, and research on artificial cultivation. The latter embraced cultivation of improved seeds, standardization of cultivation techniques, disease- and pest-elimination and prevention, introduction of new species from other countries and domestication of indegenous species. Harvest research had determined the best harvesting period for maximizing the active principle content; post-harvest handling investigations showed the optimum conditions for transport and delivery to industrial processors.

Cell- and tissue-culture techniques included *in vitro* raising of seedlings, tissue culture to save wild resources, cultivation of virus-free plants and artificial induction of multi-ploid varieties. Tissue culture was also used to obtain natural drugs, and a patent had been issued for a simple method of ginseng cell culture. A new cell engineering technology

focused on breaking through the cell wall murally so that young plants would regenerate. Chinese researchers were also working on mass suspended cell culture, cultivation of growth hormones autotrophic cells, chromosomal shift in cell culture, cultivation of ginseng cell bioplast and extraction, isolation and pharmacological aspects of ginsenoside and ginseng polysaccharide.

China operated a programme aimed at comprehensive use of medicinal plant resources. This developed non-medicinal uses such as food and beverages, condiments, pigments, perfume, cosmetics, wine-making, oils, tannins, pesticides and other uses. In several cases, medicinal uses were expanded by investigating the properties of other parts of the plant--in the case of Panax ginseng, the stem, leaves, flowers and fruits as well as the root.

Development of pharmaceutical preparations

In China, pharmaceutical R and D was directed not so much towards extracting the essential components but to developing plant-derived drugs having superior therapeutic benefits compared to the original plant drugs or their derivatives. Typically this involved exploration of pharmacological activity, adjustment of the composition of active components, extension of clinical applications and development of new dosage forms. These activities also yielded the documentation required for clinical trials and new drug applications. As in other countries, China operated a careful approval and control system for developing new commercial drugs, classifying them into four groups. Depending on their classification and exemptions, drugs were required by law to pass up to three phases of clinical trials.

Pharmacological studies yielded pharmacological profiles of plant drugs and composite recipes. Phytochemical studies, including chromatographic separation and identification, provided the basis for process development and quality control studies. Safety assessment took into account the long time trials most plants medicines had had in clinical use. Toxicological data required for clinical trial applications were therefore generally less than for synthetic drugs. For in-process quality control, methods of potency assay were developed using either identified compounds as the basis or representative compounds. Clinical trials started with preliminary evaluations for tolerance on 10 to 30 health volunteers. These were followed by pilot studies on 50 patients, later extended to 300, and by long-term trials following registration.

Proper adoption of advanced dosage forms was considered an important aspect of plant-derived pharmaceutical development. Adding to the standard forms made by granulation with inert absorbents, spray drying, fluidized granulation, microspherical granulation and micro-encapsulation were control-release- sublingual- and transdermal absorbtion preparations. An aersol spray for treatment of burns had many therapeutical advantages over conventional ointments. Capsules had replaced tinctures with astringent taste and harshness to the throat.

Quality control and standardization

The regulations standardizing the processing techniques for 13 kinds of dosage forms, the rules for their quality control and the general

regulations for identifying crude drugs were set out in the 1985 edition of the China Pharmacopoeia. The new edition, to be published in 1990 will reflect the latest advances in quality control—in chromatography, spectrophotometry, electrochemical analysis, other physio-chemical methods, biological assay, and cluster analysis and pattern recognition methods.

Polyfunctional plant

The main extraction processes now used in China were water and alcohol based, both available in batch-, semi-continuous and continuous versions. Processes included water extraction with single extractors, semi-continuous counter-current extraction with a group of extractors, warm leaching and heating reflux extraction, Soxhlet's extraction, percolation and a process for medicated wine.

China had also developed a poly-functional plant capable of extracting medicinal plants at a feed rate of up to 200 kg/day. It comprised five sub-units: pretreatment (200 kg/day), water extraction (100 kg/day), alcohol extraction (100 kg/day), spray drying (100 kg/day extract liquor) and alcohol recovery (700 kg/day). Its f.o.b. cost at a Chinese port was $795,000. A formulation plant adapted to the poly-functional plant could produce tablets, granules (by fluidized bed processing), powder, capsules, pills (honey and water pills), water extracts, medicated wine, tinctures, syrups, extracts and fluid extracts, and oral liquids.

Co-operation with other countries

Apart from China, two countries were major users of Chinese traditional medicines, Japan and the Republic of Korea. An investigation in Japan, where the Ministry of Health had approved over 200 ancient Chinese prescriptions for industrial production, showed one third of the users preferred traditional medicines for their better curative effect, one third because they made up for deficiencies in western drugs. Table 1 lists the diseases for which Chinese medicines are preferred in Japan.

China's experience suggested that as a resource for other developing countries, commercial exploitation of medicinal plants offered freedom from pollution, simplicity and safety in production, and ease of mastering the technology. Furthermore, although new molecular models based on pure phytochemicals isolated from medicinal plants was promising, it was not practical to develop such molecular models into medicines in order to meet primary health care needs of developing countries. Priority had to be given to developing plant-derived pharmaceutical preparations, i.e. galenical preparations, by using modern technologies and techniques. The advantages included fewer safety controls and only moderate investment for large production units. With local raw materials, operating costs would also be low.

As in the past, China offered to assist other countries in investigating their medicinal plant resources, draw up a practical plan for future exploitation and/or draw up a plan and have its feasibility verified. China was willing to exchange germ plasm resources of medicinal plants with countries all over the world, to investigate germ plasm resources, exploit new production, design and construct medicinal plant gardens, research

production of medicinal plants and breeding techniques, and to train personnel.

Where the drugs were also produced in China, she could supply complete technical services. Alternatively, co-operating partners could designate particular diseases as the starting point, or request assistance in modernizing or industrializing their existing traditional preparations. China's commercial design institutions were available to assist in building up enterprises or workshops with services ranging from equipment and process design through procurement to installation and start-up. China was also willing to assist with personnel training, particularly at her pharmaceutical institutions of higher learning. Training could be given in industrial production, investigation of natural resources, cultivation of medicinal plants, drug analysis and sythesis, pharmaceutical preparation and pharmaceutical engineering.

TABLE 1

Diseases treated in Japan for which Chinese traditional medicines are preferred:

Vegetative nerve functional disturbance	
influenza	chronic hepatitis
climacteric syndrome	bronchial asthma
chronic constipation	psychosomatic disease
chronic nephritis	chronic gastritis
nasal allergic reation	hypertension
headache	diabetes
neurosis	chronic rheumatoid arthritis
acute and chronic rhinitis	stiff shoulder
dysmenorrhea	hypotension
prostatic hypertrophy	atopic dermatitis
gastroptosis	chronic diarrhoea
comedo	chronic bronchitis
neurosis	gonarthrosis deformans
obesity	urticaria
haemorrhoids	neurogenic frequency of urination
cataract	cholelithiasis
asthmatic bronchitis	menstrual disorder
cardionneurosis	acute diarrhoea
stomatitis	gastro-duodenal ulcer
acute hepatitis	chronic pancreatitis
chronic nasosinusitis	acute cystitis
acyesis	enuresis nocturna

IV. DEVELOPING COUNTRIES' PHARMACEUTICAL CO-OPERATION NEEDS AND OFFERS

Medicinal plant-based industrial technology and services offered by selected Chinese Institutions are listed in annex II. Alongside China, a

number of the countries represented at the Workshop were in a position to offer technologies and services to other developing countries in the field of plant-based pharmaceuticals. These are listed in annex III.

The invited countries' technical co-operation needs in the field of industrial utilization of medicinal plants were ascertained by means of questionnaires. Those forming the basis of discussions with the Chinese delegations were as follows:

Guatemala

Although Guatemala had a strong interest in developing industrial and commercial uses of medicinal plants and their derivatives, its industry faced technical and economic constraints. There was a lack of specialized personnel, especially trained pharmaceutical and chemical engineers. There was also no national quality control laboratory serving the pharmaceutical industry in the public sector.

International co-operation was required in the form of expertise on botanical classification and identification, plant cultivation, technical production and commercialization.

Advice may be needed on a national strategy for developing native plants and products, for standardization of procedures and for registration of phytotherapeutical products.

Since 1988, Guatemala had had a National Commission for Medicinal Plants (CONAPLAMED) with two immediate objectives: to evaluate the potential of indigenous flora and list the priority species suitable for industrial utilization, and to develop process technology and trained manpower required by the plant-derived pharmaceutical processing industry. The former suggested a requirement for expert assistance in carrying out ecogeographical surveys and ethnopharmacological studies.

This interest was in line with the 1988 Chinese findings which proposed co-operation in seven areas:

- Ethnobotany (study of traditional systems)
- Agronomy (botanical and genetic improvement, preservation and propagation)
- Pharmacology (bioassays of medicinal plants and active principals, and toxicological trials)
- Phytochemical studies related to the above
- Pilot plant studies (technical parameters for production plant), establishment of factories and technical assistance to existing factories
- Marketing strategies for internal and export markets.

Subsequently, CONAPLAMED had indicated an interest in commercial co-operation (joint ventures, licensing and co-production) to establish plant-derived industries.

Short-term experts were required to help expand experimental cultivation, and to advise on post-harvest technology and marketing strategy. Longer-term

experts were needed for chronic toxology, pilot plant operations, quality control and elucidation of chemical structures.

On-the-job training was needed in experimental and clinical pharmacology, quality control and pilot plant operations. Study tours would be of interest covering pilot plant operations in other countries, ethnobotanic surveys and the role of medicinal plants in primary health care. Guatemala also sought animal house and quality control equipment.

India

In Himachal Pradesh in the North of India, the state government was boosting propagation by means of a number of measures in the area of raw material supply taken in conjunction with the Council for Scientific and Industrial Research. These included promotion of herbal gardens, cultivation by farmers, cultivation under integrated rural development programmes and demonstration farms. An exchange of experience in these fields with China and other countries by means of study tours would be of interest.

Although Jogindernagar had a model centre for activities connected with medicinal plants, a rehabilitation programme was needed to modernize plant and equipment. This would enable it to function as a service centre offering demonstration facilities and training in four areas:

- o Quality control of raw materials and products
- o Consultancy, documentation and dissemination of information on latest developments
- o Latest agro-technology for cultivation through a network of herb gardens
- o Post-harvesting technology (collection, packaging, storage, marketing and management) and training.

Technical co-operation may also be possible to overcome problems such as supply of adulterated raw material, lack of drug standardization in relation to raw materials, and lack of modern processing technology for manufacturing mixtures, extracts, powders, tablets, ointments and other dosage forms.

The existing industry lacked R and D facilities and suffered from poor quality and untimely availability of raw materials. Quality control of raw materials was also lacking. Industry was neither introducing new products nor increasing its production, its product packaging was poor and it lacked marketing and modern management skills. Insofar as such problems could be solved with reorientation of management, study tours of other countries' facilities and manufacturing units as well as management training might be provided under TCDC arrangements. Expertise and on-the-job training may also be arranged. Given the abundant raw materials available in Himachal Pradesh, consideration may also be given to joint ventures.

Above all what was needed was an institution-building programme for the Jogindernagar centre so that it could provide analytical services for raw material quality assessment, assistant industry with introduction of modern technology, design and improve technological processes using the centre's pilot plant, develop and demonstrate improved agro-techology practices, disseminate information to the field, and provide consultancy services to farmers and entrepreurs.

Indonesia

At the commercial level, Indonesia would be interested in acquiring certain Chinese technologies in the longer run. For the present, the Directorate of Traditional Drugs Control in the Ministry of Health would welcome an opportunity of sending its specialists to China for on-the-job training in production processing (particularly in extraction), phytochemical analysis and research in the area of final drug forms such as capsules and tablets.

Nigeria

Although Nigeria had abundant raw materials, the local phamaceutical industry essentially sourced the materials for its active components abroad. The policies to change this, already in place, had three objectives:

- o Improvement of local capability in drug manufacture
- o Promoting research on traditional remedies with a view to developing some of them for regular use in the health care system
- o Stimulating R and D on basic chemicals and other pharmaceutical raw materials for production, compounding and formulation of drugs.

The commitment of the Government was also demonstrated in its establishment of the National Institute for Pharmaceutical Research and Development (NIPRD). Among other things, NIPRD would establish the specifications for the control of quality and safety of herbal medicines. This would mean establishing pharmacological and toxicological profiles of single- and multiple-plant herbal products. Formulation and packaging practices would have to be established to prevent deterioration during storage. NIPRD would also establish the scientific basis for rational use of plant-derived medicines and develop educational campaigns to enhance their acceptability, especially to the urban public.

Training would be required to expose the core of pharmaceutical scientists, chemists, botanists, chemical engineers and microbiologists to techniques and know-how required for production and pilot plant investigations of medicinal plant processing.

In general, Nigeria was looking for supplies of spare parts and training of maintenance staff.

At a commercial level, industry would be interested in technology transfer (especially concerning formulation of dosage forms), co-production arrangements, equipment and raw material sourcing and joint ventures. The Federal Ministry of Health was exploring ways to commercialize its drug manufacturing laboratory and wished to draw on others' experience in that area.

Short-term experts were required to advise on formulation and development of drugs from medicinal plants, on product quality, resource assessments, pharmacological screening, prescription preparation and production-scale manufacturing; long-term experts to assist in plant design and layout, product quality and drug synthesis. On-the-job training was sought in sourcing of raw materials, purification, analysis and compound identification, pharmacological studies, drug synthesis and computational

chemistry, design and formulation of drugs from medicinal plants. Likewise, study tours on raw material sourcing, drug development, and commercialization and marketing of plant extracts would be helpful. In the equipment area, Nigeria needed chromatographs and small-scale plant for extracting active ingredients from botanical plants.

Pakistan

Although Pakistan was endowed with considerable medicinal plant wealth, these materials were being imported in large quantities either as raw materials or pure drugs obtained from them. There was an opportunity, therefore to utilize this national source both for self-sufficiency and to reduce the expenditure on imports. Currently only three or four indigenous plants were processed to yield pure drugs.

Although annual production of santonin reached 2.5-3.0 tons in the early 1970s, the market dwindled leaving only a small consumption of essential oils as the outlet for the cultivated crop of Artemisia maritima. One possible substitution crop was Chrysanthenum cinerariaefolium, whose dried flower heads could be used for pyrethrum, an active insecticide. Chrysanthenum cinerariaefolium had been experimentally cultivated in the 1970s and an ideal ecology found. One Pakistan manufacturer committed to exporting diosgenin had had difficulty in obtaining adequate quantities of Dioscorea deltoidea, even though it grew wild in several localities. The present methodology for collecting Dioscorea was unsatisfactory and there was a danger of complete depletion. A concerted programme of regeneration, cultivation and propagation was needed together with planned collection on scientific lines. Introduction of higher yield D. composita and D. floribunda was also desirable.

Although production of ephedrine from Ephedra gerardiana had been discontinued recently, it was restarted by another manufacturer with an output that met only 50 per cent of demand. Efforts were required to enhance production by means of improving raw material quality: ephedrine content had dropped 10 per cent from one source.

The Pakistan Council for Science and Industrial Research (PCSIR) had developed an acid process for manufacturing mono-ammonium glycyrrhizinate from Glycyrrhiza glabra (licorice) as an import substitution product. There was considerable export potential both for this and the co-product 18-beta-glycrrhatinic acid. In addition there was potential for exporting large quantities of dried licorice extract.

Mentha arvensis var. piperascens had been introduced recently from Japan as a source of menthol and mint oil. Experimental cultivation was under way at two locations.

PCSIR had also developed a technology for producing aescin (used in treatment hemorrhoid and veinous congestions and as an anti-oedemic drug). However in Pakistan there was currently no use of the fruits of Aesculus indica, the raw material for this.

In the context of the above, Pakistan institutions would be interested in receiving short-term experts or consultants plus on-the-job training in the fields of agronomy, agro-technology, plant breeding and genetics of

medicinal plants. On the same basis they would also be interested in assistance in the areas of biological assays and tissue cultures. An exploratory study tour would share experience in pilot plant processing of medicinal plants.

Also requested if available were selected germ plasms and reference samples.

Philippines

[illegible]ppines reported an interest in undertaking studies in possible import substitution of drugs based on medicinal plants. In addition technology and short-term expertise were needed on storage of raw materials and finished products in order to maintain their potency. A long-term expert was requested in phytochemistry and on-the-job training in quality control and bioassays.

The basis of a Philippine plant-based pharmaceutical industry was provided by the National Drug Policy's goal of self-sufficiency in drugs and its incentives for private investors to take up manufacture of raw and semi-processed pharmaceuticals. Industrially produced plant-based remedies would also have to comply with the policy's other requirements of quality assurance, rational use of drugs and a rational procurement programme by the Department of Health.

Self-sufficiency was the incentive for investigations and studies on traditional herbal medicines by the Philippine Council for Health Research and Development. Their results were being translated into regular medicinal preparations. Many of the thousands of such preparations in current use had been scientifically validated and passed toxicologically and teratologically. They were now being considered for processing and manufacture, with priority being given to those with the widest use and benefits. Vitex negundo, for example, had been found effective for fevers, as an expectorant and bronchodilator and would be made in the processing plants of the Department of Health. Two out of three planned industrial-size manufacturing plants were in operation. A smaller-scale plant was projected as an R and D unit.

The main problems facing the young industry were logistical support, skilled manpower and high capital requirements. There was a lack of experienced scientists to undertake sophisticated studies of plant-active fractions, pharmacologists to determine their value as therapeutic agents and technical staff to undertake industrial activities. As elsewhere, lack of familiarity with herbal pharmaceuticals among medical professionals and training hospitals was reflected in popular equation of herbal preparations with primitive and unscientific methods of treatment.

The focus today was on isolating the active ingredients in medicinal plants. Another step was to determine if the identified pharmacologically-active components would be cost-beneficial if synthesized. Clinical studies were necessary to overcome the variations in medicinal plants with time and between sources. Fastidious biological and clinical assays would be necessary before products could be released for public consumption.

Romania

Romania had a commercial interest in joint production of plant-based medicines in the fields of anti-rheumatic-, anti-inflamatory and hepatoprotective agents and vitamin complexes. The imminent privatization of pharmaceutical enterprises offered new opportunities to develop new medicines under co-operation arrangements. The possibilities for such economic co-operation could be established by means of study tours.

Technology transfer, co-production, joint venture arrangements, were also sought in manufacture of rapid, high-efficiency concentrators and liquid separators.

Joint research was proposed in anti-cancer medicines, hormone-like medicines, contraceptives, immuno-modulation medicines, vegetal-origin precursors of prostaglandin, tissue and cell cultures in vitro for active biological substances and high-pressure extraction by means of supercritical CO_2-gas.

Researchers were working on plant-based medicines with anti-viral-, anti-cancerous-, immunomodulator-, or hormonal actions. They were extracting active principles with cell- and tissue cultures of medicinal plants, and preparing purified extracts using supercritical fluids. Technical and scientific co-operation interests also included medicines with contraceptive-, anti-parasite-, anti-tumor and hormonal action using active principles from medicinal plants. A facility going into operation in 1991 using supercritical carbon dioxide could be the basis of international co-operation applying the technique to extraction of selected Romanian medicinal plants.

In this context, Romanian research institutes were interested in receiving a short-term expert or consultant and in on-the-job training in high-pressure extraction using supercritical gases. Equipment may also be sought in this connection. A short-term expert and on-the-job training was sought on jelly formulations with anti-inflamatory and antiseptic action.

Sri Lanka

A major constraint slowing the development of Ayurveda, the traditional herbal medicine system originating in India, was the lack of an adequate and regular supply of authentic Ayurvedic drugs. Cultivation of medicinal plants had not kept pace with demand, wild resources were declining fast due to over-exploitation or the absence of an organization for collection and curing. There was thus considerable scope for increased production, conservation and systematic collection.

Sri Lanka had been supplying raw materials such as Rauwolfia serpentina, Catharanthus roseus and Gloriosa superba to Western pharmaceutical firms, which after processing re-exported them to other developing countries at high prices. Instead, initial processing could be effected in Sri Lanka either by developing technology or acquiring it through collaboration. The Ceylon Institute of Scientific and Industrial Research had developed methods for initial processing of C. roseus and G. superba, for example.

In general the equipment used in Sri Lanka factories was 20 to 30 years old and required modernization with appropriate modern technology. For example, only limited modernization in powdering, grinding, using superheated steam and bottling had been carried out. Changing the technology was, however, a sensitive issue with a generally conservative medical profession.

Because the Ayurvedic approach used the whole plant or a combination of plants, laying down of standards for preparations with a vast array of chemical constituents involved many difficulties. Two institutions were now conducting research on quality control of Ayurvedic drugs.

There was also an urgent need for a central laboratory to study the toxicities of drugs used over long periods, to verify the claims of some remedies and to carry out pharmacological screening.

Sri Lanka was interested in sourcing selected medicinal plants for cultivation along with cultivation know-how. It could co-operate with other countries also in improvements in production of Ayurvedic drugs, in packaging and storage and in production of flavour and perfumery compounds.

At a commercial level, co-production or joint ventures would be considered with the aim of preparing or isolating commercially important compounds. Sri Lanka sought sources and prices of low-cost equipment for plant-based drug manufacturing factories. Co-operation was also proposed for preparation of perfumery products from local essential oils and in preparing pharmacological assays of plants and drugs.

Short-term consultants and related study tours were requested for modern techniques in cultivation of medicinal plants and in upgrading technologies for Ayurvedic drug manufacture. Assistance was required in the form of basic information on cultivation practices, climatic and soil requirements etc. for species currently imported or having good export potential. Access was needed to quality planting materials and information on post-harvest practices and storage. Market information was needed on medicinal plants and their derivatives, quality requirements, major buyers, prices etc. Staff required training in modern cultivation techniques, and in organization and operation medicinal farms.

Study tours would also be of interest in production of drugs from medicinal plants.

There was also a great need to upgrade outdated equipment at the ayurvedic drug factory in Sri Lanka and to source equipment for pharmacological assays.

Turkey

Although Turkey was rich in flowering plants and had a long history of using herbal medicines, production of some traditional drugs used primitive techniques and few plant-based raw materials were processed on an industrial scale. Facilities for production of plant extracts were under-utilized owing to lack of appropriate technologies for production. Manufacturers were also reluctant to produce plant-based materials while internal demand was too small and exports uncompetitive.

Turkey exported a large number of crude drugs, however. Uncontrolled collection was causing irreversible destruction and a project to promote cultivation of medicinal and aromatic plants had lost momentum. The lack of restrictions on exporting crude plant drugs had deprived local manufacturers of low-priced materials.

Among projects to diversify output from an alkaloid plant, research was in progress to produce caffeine from tea wastes, and tannin from oak galls.

A medicinal plants research centre, in operation since 1984, had created two data bases--one with botanical-, geographic-, folkloric-, pharmacological-, chemical-, analytical-, economic-, procedural- and trade information, the other with published information on medicinal and aromatic plants in Turkey. A pharmacological screening laboratory for biological activity assessment of medicinal plants was now being established and preparations were in hand for a formulation facility for pharmaceuticals.

Turkey was interested in all kinds of commercial co-operation with other developing countries including technology transfer, joint ventures, co-production and licensing. In addition she proposed information exchange, provision of experts and feasibility studies. Short- and long-term experts, on-the-job training and study tours may be sought in design engineering and pharmaceutical formulations.

United Republic of Tanzania

Tanzania had a large variety of medicinal plant species that divided into five groups:

- Medicinal plants growing in quantity (spontaneous or cultivated) that were well-studied, documented in international pharmacopedias and could be used directly, e.g. Acacia catechu, species of Datura and Strophanthus kombe.

- Plants used in traditional medicine but requiring testing for therapeutic activity, e.g. Argemone mexicana, Citrullus lanatus and Solanum incanum.

- Plants used in traditional medicine with promising clinical effects but not yet thoroughly chemically and pharmacologically screened, e.g. Securinega virosa and Centella asiastia.

- Medicinal plants containing alkaloids, glucosides and saponins that could be used as a source of pharmaceutical products after screening, e.g. Zanthoxylum Chaly beum and Tamarindus indica.

- Medicinal and aromatic plants under experimental cultivation since 1984 using imported seeds. Production of several dosage forms were under way from Calendula officinalis, Coriandrum sativum, Matricaria chamonilla, Cynara scolymus, Saponaria officinalis and Plantago lanceolata.

The Government wished to emphasize research on and ultimate use of effective, safe herbal drugs in its health institutions. A problem, however, was to provide information on efficacy, safety and dosage to

allopathic practitioners. Even with plant-derived drugs used in other countries it had proved difficult to obtain such information.

Tanzania lacked qualified and experienced pharmaceutical technologists well versed in formulation and standardization of herbal drugs. She looked to China among others for such expertise. Tanzania also sought expertise on the agro-technology of medicinal plants, to improve yields and quality of cultivated crops.

V. UNIDO TECHNICAL ASSISTANCE IN THE FIELD OF INDUSTRIAL UTILIZATION OF MEDICINAL PLANTS

UNIDO technical assistance in the field of industrial utilization of medicinal plants during the past decade totalled more than $30 million. As a result, industrially-produced preparations were manufactured and introduced in health care in Burkina Faso, Guatemala, Madagascar, Nepal, Rwanda, Sri Lanka, Thailand, Turkey, United Republic of Tanzania and Viet Nam. Fundamentally UNIDO's approach in each case was institution and infrastructure strengthening. In having available a wide variety of specialists--botanists, agronomists, analytical chemists, phytochemists, pharmacists, pharmacologists, chemical engineers and industrial engineers--each country could itself develop the technology for industrial processing. Each new product was a step towards self- sufficiency in therapeutic agents for a national health programme, a small reversal of the catastrophic disproportionality in the availability of drugs for medicinal purposes in the developing world.

In assisting countries to strengthen their infrastructure for industrial processing of medicinal plants, UNIDO focused primarily on eight aspects of R and D:

- Selection of plant species of reputed therapeutic value and suitable for industrial processing;
- Assurance of quality and consistency in the plant raw material;
- Validation of claims of traditional therapies using modern methodologies (in conjunction with WHO)
- Developing standards of quality assessment and analytical methods;
- Developing modern process technology (at bench and pilot scale)
- Determining the role of traditional-system based remedies in current health-care systems;
- Investigations leading to development of new drugs (particularly where current remedies were unavailable or unsatisfactory);[1]
- Development of technology packages for industrial use.

Individual programmes covered economic mapping, plant species selection (including domestication and preparation), biological assessment, chemical analysis and quality control methods, process technology development, new products (including packaging and storage), and regulatory aspects of product introduction.

A typical UNIDO technical assistance programme combined three elements: human resource development, transfer of technology and pilot-scale processing. Training was conducted through field experts on site, and through fellowships and study tours to centres where the relevant technology

was well developed. Technical co-operation among developing countries (TCDC) had been used in this connection with training programmes in China, India, Romania and Turkey, and ad hoc training in Hungary, Madagascar, Thailand and Sri Lanka. In UNIDO's view, there was still considerable unused potential for such activities.

Transfer of technology required at least a threshold level of national expertise in several disciplines; a number of UNIDO programmes had therefore focused on strengthening an appropriate centre in areas such as agronomy, organic chemistry, instrumental analysis, pharmacology, process technology and product formulation. These in turn could become focal points for technology diffusion within the country and a local resource centre for a subregion.[2]

To remedy a major constraint in the form of a lack of suitable pilot-scale facilities and expertise in chemical process technology, UNIDO developed a polyvalent pilot plant concept. This enabled the following operations: crushing of raw materials, percolation, solid-liquid and liquid-liquid extraction, solvent recovery, filtration, crystallization, steam distillation, and oil-water separation. UNIDO was still seeking simpler, more versatile and less costly designs, but such plants had already been installed under projects in Nepal, Turkey, the United Republic of Tanzania and Viet Nam; others were scheduled for Guatemala and Madagascar.

During a decade of project activity, the results of UNIDO efforts to support industrial development and utilization of medicinal plants included generation of: technologies for industrial processing of marketable pharmaceutical products for internal markets and primary health-care use, modern methods for production and quality control of tradition formulations, pharmaceutically useful phytochemicals for export and internal use, standardized extracts, and para-pharmaceutical products and other derivatives. In addition, national specialists were beginning to acquire the sophisticated methodology of modern natural-product related drug development, including regulatory safeguards and good manufacturing practices.

VI. RESULTS OF BILATERAL DISCUSSIONS ON CO-OPERATION PROJECTS

The bilateral discussions, aimed at identifying specific co-operation opportunities were held in eleven parallel sessions on 19 October 1990. A total of 25 working agreements between Chinese representatives and their counterparts from other countries were concluded. They included exchange of information, preparation of detailed project proposals for technology transfer and feasibility studies and supply of components and equipment.

UNIDO together with SPAC would undertake follow-up activities to promote practical realization of the working agreements, in particular by means of self-financed study tours and the use of national funds for TCDC.

The results of the bilateral discussions are summarized in annex V.

VII. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the plenary discussions during the workshop, it was generally agreed that in the past four decades China had made great strides in developing industrial uses of medicinal plant resources. The contribution of 25 per cent of gross output value of the nation's pharmaceutical industry had been a considerable achievement.

The invited participants recognized the relevance for them of China's experience in seven main areas: assessment of plant resources; adoption of measures to protect medicinal plants from over-exploitation and lack of planning; manufacture of preparations from medicinal plants; the development of pharmaceutical dosage forms; the design and engineering of production facilities; manufacture of machinery and equipment; and strict quality control arrangements for pharmaceutical products introduced on a commercial scale, which further enhanced the acceptability of plant-derived medicines in health-care systems.

Acknowledging past activities where China had sent its experts to African and Latin American countries to help them investigate their medicinal plant resources, the workshop appreciated SPAC's offer to continue such services coupled with advice on the results in the form of exploitation plans and feasibility studies. Appreciated also was China's offer to make available through further work with UNIDO and other United Nations agencies the vast store of accumulated data, both on the plant materials themselves and the processes and technologies for exploiting them industrially, the technical services that could put such information to practical use in other countries and the design know-how for the equipment involved. China would also help with training personnel in industrial production of medicinal plant preparations, investigation of natural resources, cultivation of medicinal plants and pharmaceutical engineering.

In this respect the invited participants expressed their desire for co-operation with SPAC and through it with China's manufacturers and technical institutions. Technical and economic co-operation with developing countries such as China, it was felt, would help both sides to learn from each others' experience, and to provide equipment and technology suited to their countries.

Recalling the recommendations of the 1982 UNIDO sponsored workshop held in Beijing, and the recent inter-regional meeting on pharmaceuticals in New Delhi, the workshop made the following recommendations:

Technical co-operation

1. The preliminary agreements negotiated at the workshop as the springboard for technical and economic co-operation between Chinese institutions and manufacturing enterprises and their counterparts in other countries be actively followed up by both the participants and the Governments of the countries they represent, where possible using national TCDC funds or funds available from multilateral sources as a catalyst.

2. UNIDO intensify its technical assistance activities to create or strengthen developing countries' industrial base for manufacture of medicinal plant-based pharmaceuticals, especially with respect to

generating, inter alia, indigenous capability in agro-technology; in this respect UNIDO should make available its designs for polyvalent pilot plants to institutions in developing countries on request.

3. Recognizing the need to develop medicinal plant-based industries as an essential means of health care in most developing countries, which at the same time were not able to achieve such an objective without external financial and technical assistance, UNIDO is urged to approach bilateral and multilateral funding agencies such as the World Bank with a view to expanding the UNIDO programme supporting the industrial utilization of medicinal plants.

Regional activities

4. Recognizing the usefulness of China's experience in the field of industrial exploitation of medicinal plants, UNIDO should examine the possibility of establishing a regional centre of excellence in China designed to share China's technical expertise and information on plants and plant products with other developing countries. This could be the focus of regional activities such as information and data exchange, manpower training, R and D activities, engineering services and supply of equipment.

5. Endorsing the approach of UNIDO towards systematic development of medicinal plant-based industries in developing countries, preparatory work for the forthcoming regional Consultation meeting scheduled for 1992-1993 should be based on the following topics and issues:

(a) An integrated approach towards the development of industrial utilization of medicinal, aromatic and other plants containing industrial natural products (botanical pesticides, tanins, pigments etc.), and mechanisms for setting-up a phytochemical and phytopharmaceutical industry;
(b) Establishment of a mechanism for subregional and regional co-operation for the preservation and propagation of medicinal and aromatic plants and of gene resources;
(c) Initiatives leading to the development of indigenous skill and technology for processing of plant materials, including design and fabrication of relatively inexpensive equipment for this purpose;
(d) Establishment of subregional, regional and international information networks and inter-institutional links related to the technology for industrial processing of medicinal plants;
(e) Initiatives for international co-operation for the development of methodologies for the assessment of therapeutic value of medicinal plants (with the assistance of WHO in this aspect), their processing as raw materials, and as pharmaceutical preparations; the regulatory needs for introducing plant-derived pharmaceuticals from traditional pharmacopoeia into health care delivery systems;
(f) International co-operation and mechanisms in relation to the financing of selected research and development activites and joint venture projects;
(g) Co-operation in the establishment of research and development capabilities in developing countries for medicinal and aromatic plants and the development of joint R and D activities at regional and international levels.

6. As the premier country in providing phytopharmaceutical products as health cover for its people, China should consider the possibility of hosting the 1992-1993 regional Consultation meeting at an appropriate location; similar regional meetings should be considered for the Africa and the Latin America and Caribbean regions in 1994;

7. In view of the importance of high technology for the development of raw material resources, UNIDO should request the International Centre for Genetic Engineering and Biotechnology (ICGEB) or similar institution to establish germ plasma and seed banks to preserve medicinal plant resources, and through tissue cultivation make seedlings available to developing countries.

Documentation and information

8. Subject to availability of funds, SPAC (assisted by UNIDO) edit and publish the workshop documentation as its proceedings, distributing copies to the participants and to interested libraries and institutions.

9. UNIDO, in collaboration with SPAC and other international organizations where appropriate, publish in English China's industrial quality control standards for plant-based pharmaceuticals, including their raw materials, intermediates (extracts), excipients etc., especially those appearing in the Chinese Pharmacopoeia (1990 edition).

10. UNIDO take all necessary measures (where needed including provision of technical inputs) to enable SPAC to translate and publish in English its compendium of plant-derived natural products of pharmaceutical interest--both the 1986 edition in Chinese and its 1990 supplement (now ready in manuscript form) and make it available to interested developing country institutions.

11. UNIDO, in collaboration with other international organizations where appropriate, recommend initiatives for creating an information network on industrial processing of medicinal and aromatic plants (INPROMAP) and as the focal point of such a network, in assisting China in building a computerized

data base containing all available information on laboratory-, pilot- and industrial scale processing of medicinal plants together with analytical procedures related to quality assessment of raw materials, intermediates and final products and formulations.

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(1) Maladies for which ethnomedicine can provide remedies perhaps superior to drugs of medicine include tropical diseases (antimalarials, antifilarials), anti-rheumatics, immuno-modulators, immuno-stimulants and adaptogens, antiviral agents, hepatoprotectors, rapid wound- and ulcer-healing agents, and cerebral stimulating or sedating agents; see also table 1.

(2) Successful technology transfer centres assisted by UNIDO include: the Royal Drugs Research Laboratory, Kathmandu (Nepal); the Medicinal Plants Research Centre, Eskirsehir (Turkey); the Centre for Pharmaceutical Research, Butare (Rwanda); the Traditional Medicine Research Centre, Dar-es-Salaam (United Republic of Tanzania); Centre Nationale Recherche Pharmaceutique, Antannanarivo (Madagascar); Institute of Material Medica, Hanoi (Viet Nam); and the Thai Institute of Scientific and Technological Research, Bangkok (Thailand).

Annex I
Work programme

Monday 15 October

Opening session

Welcoming addresses
Qi Moujia, General Director, SPAC
Mr. Zhang Gouquan, Deputy Director, DIR, MOFERT
Mr. Fan Huishun, Chief, Section for Economic Co-operation among Developing Countries, UNIDO

Election of Bureau (Chairman, Vice-Chairman and Rapporteur)

Industrial Utilization of Medicinal Plants in China—Ren Dequan, Director, Science, Technology and Education Bureau, State Pharmaceutical Administration of China (SPAC)

On the Problems of Resourcology for Industrial Utilization of Medicinal Plants—Prof. Zhou Ronghan, China Pharmaceutical University

Development of Pharmaceutical Preparations from Medicinal Plants by the Use of Modern Technologies and Techniques—Prof. Liu Yuqun, Tianjin Institute of Pharmaceutical Research

Quality Control and Standardization of Drugs Based on Medicinal Plants—Prof. Meng Xianshu, Prof. Chen Yingjie, Shenyang College of Pharmacy

Polyfunctional Plant for Extraction of Medicinal Plants, Shanghai Pharmaceutical Industry Design Institute

Co-operation with China's pharmaceutical industry based on medicinal plants - its institutions and enterprises—UNIDO consultant, Prof. Li Xian, Shenyang College of Pharmacy

General discussion

Tuesday 16 October

UNIDO activities in the field of industrial utilization of medicinal plants—UNIDO Special Technical Advisor, Dr. R.O.B. Wijesekera

Technical and economic co-operation among developing countries to promote industrial utilization of medicinal plants—UNIDO Industrial Development Officer, Peter Ellwood

Issues in the development of plant-based industrial pharmaceuticals in developing countries—UNIDO Special Technical Advisor, Dr. Muhammad Majid

Industrial utilization of medicinal plants in participating countries—present status and needs (presentations by participants)

Wednesday 17 October

Visit to Guang An Men Hospital (Chinese Academy of Traditional Medical Sciences)

Video presentations

Thursday 18 October

Visit to Tianjin Da Ren Tang Drug Factory, Tianjin Sixth Pharmaceutical Factory and the Tianjin Pharmaceutical Research Institute

Friday 19 October

Bilateral discussions and signing of agreements

Saturday 20 October

Bilateral discussions and signing of agreements

Adoption of draft conclusions and recommendations

Closure of the workshop

Sunday 21 October

Departure for Shanghai

Monday 22 October

Visit to the Shanghai Insititute of Pharmaceutical Industry and the Shanghai Pharmaceutical Industry Design Institute

Tuesday 23 October

Visit to the Shanghai Chinese Medicine Works

Annex II
Medicinal plant-based industrial technology and services offered by China

Name of institution

Shanghai Institute of Pharmaceutical Industry
- Pharmacology and toxicology
- Analysis and identification of plant-based medicines
- Phytochemical studies
- Collaboration in R and D of plant-based medicines
- Development of pharmaceutical preparations
- Adaption of equipment from chemical and other industries

Tianjin Traditional Chinese Medicine Corporation
- Development and production of traditional Chinese medicines
- Chinese patent medicines, medicinal plant raw materials, healthy foods, tonics and cosmetics
- Health food restaurant
- Specialized processing machinery for certain dosage forms
- Industrial management expertise
- Training programmes

Shanghai Pharmaceutical Industry Design Institute
- Indentification of Chinese equipment manufacturers interested in co-operation with counterparts in other countries
- Pilot plants
- Equipment selection and engineering design of single equipment items, packaged equipment and production lines
- Design of extraction and formulation plant, including feasibility studies and engineering services

Shenyang College of Pharmacy
- Phytochemistry and pharmacognosy
- Pharmacology and toxicology
- Quality control and standardization
- Formulation and development of dosage forms
- Personnel training
- Preparation and verification of authentic samples for use in quality control
- Collaboration in R and D of plant-based medicines
- Transfer of production technology

China Pharmaceutical University
- Ethnobotany, taxonomy and chemotaxonomy
- Agronomy (including cell- and tissue cultivation and genetic improvement)
- Pharmacognosy
- Phytochemistry
- Pharmacology and toxicology
- Personnel training
- General investigations of medicinal plant resources (locally or on a national scale)

Collaboration in R and D of plant-based medicines

Tianjing Institute of Pharmaceutical Research

Sponsored or joint pharmaceutical development and toxicological assessment of plant-derived medicines
Identification of crude drugs
Joint quality control investigations of plant-based medicines
Sponsored or joint development of phytopharmaceuticals by modern techniques
Information on medicinal plants and plant-derived pharmaceuticals
Exchange of publications
Authetic samples of plant origin
Technical training in areas of pharmacology, phytochemicals and pharmaceuticals for development of plant-derived medicines

Annex III

Medicinal plant resources, pharmaceutical technologies and other TCDC services offered by invited particants

CONAPLAMED (Guatemala)	Short-term experts, on-the-job training and group training in experimental pharmacology of anti-inflammatory, antispasm, diuretic, cicatrizant, hypoglycemic and antimicrobial drugs; short-term experts in chemical engineering aspects of natural products, microbiology, ethnobotany, agronomy and phytochemistry; on-the-job training in phytochyemistry, phytotherapy and propagation technology; short-term group training in experimental pharmacology and phytotherapy; consultancy services in propagation technology, experimental pharmacology, pilot plant extraction (tinctures, essential oils and crude extracts); research services in propagation technology, pharmacological and antimicrobial screening. COMPLAMED also operates a data base on Guatemalan medicinal plants.
Government Ayurvedic Pharmacy, Himal Pradesh (India)	Short-term experts on production of 110 plant-based medicinal items; research services on phytochemicals. The CSIR Institute at Palampur is carrying out trials to introduce Eucalyptus youmanii, Lupinus alba, Matricaria chamomile, Pinus patula, Pimpnella annisum, Rosa demascena and tube rose.
Directorate-General of Drugs and Food Control (Indonesia)	Short-term experts and training in setting up domestic medicinal gardens, phytochemical analysis, toxicity testing and clinical trials.
Pharmacy Division Ministry of Health (Malaysia)	The School of Pharmaceutical Sciences at the University of Science is screening some local plants for their pharmacological activity. Malaysia also has an active policy for registering and screening (for safety and acceptable quality rather than efficacy) herbal remedies offered in pharmaceutical dosage forms.
National Institute for Pharmaceutical Research and Developments (Nigeria)	Nigeria is potentially a major source of raw materials for plant-based medicines, e.g. Datura stramonium, Clavicepts purpurea, Digitalis lanata, Cassia acutifolia, Pilocarpus jaborandi, Eucalyptus globulus, Occimum gratissimum, Datura metel and D. stramonium, Mucuna pruriena and M. sloanei, Colchicum autommale, Urginea maritima and Ricinus communis; Abrus precatorius, Anona senegalensis, Cyperus esculentus, Landolphia flonda, Lawsonia intermis, Maringa oliefera, Ricinus communis, Syzigum guinense, Acacia senegal, Albyzia verrugini and Xanthomonas capaarestris are a local source of binders used in tabletting.

School of Pharmacy Lagos University College of Medicine (Nigeria)	Short-term, on-the-job training, group training, consultancy and research services in pharmacology, analytical chemistry, pharmacognosy, synthesis, formulation and medicinal chemistry.
Raw Materials Research and Development Council (Nigeria)	Short-term experts on plants in traditional medicine, extraction and purification, drug evaluation and testing, chemical analysis and determination of compounds; on-the-job training in extraction and purification processes, drug evaluation and testing, and chemical analysis; group training in plant identification, extraction and purification, chemical analysis, and evaluation and testing; consultancy services in plant identification, extraction and purification, chemical analysis, compound identification, pharmacological studies, clinical testing, drug information and reference standards; research services in identification and evaluation of natural resources for drugs and pharmaceutical utilization, evaluation, preservation, purification and standardization of plant preparations, drug distribution storage, stability and shelf life.
Food and Drug Administration and Control Department, Federal Ministry of Health (Nigeria)	Short-term experts drug regulations and controls, quality control and drug manufacture; on-the-job and group training in quality control and drug procurement.
Medicinal Botanic Centre, PCSIR Laboratories (Pakistan)	Short-term experts in chemical investigations, pilot plant processing of medicinal plants and laboratory techniques. Local industry cultivates Artimisia maritima as a source of santonin and (experimentally) Mentha arvensis as a source of menthol and mint oil, and Chrysanthemum cinerariaefolium as a source of pyrethrum and Ocimum basilicum to produce Basil oil. It has the technical know-how, albeit insufficient raw materials even for local demand, to process Dioscorea deltoidea (into diosgenin), Ephedra gerardiana (into ephedrine), Glycyrrhiza glabra (for ammonium glycyrrhizinate and 18-beta-glycyrrhentinic acid), Aesculus indica (into aescin). Regeneration of medicinal plants suchas Acorus calamus, Atropa acuminata, Digitalis purpurea, Digitalis lanata, Dioscorea deltoidea and Valeriana wallichii have been made.
Cotabato Regional Hospital (Philippines)	On-the-job training in cultivation, harvesting, storage, processing, packaging, quality control and bioassay of medicinal plants. Commercial plants manufacture an analgesic, expectorant-bronchodilator in tablet form based on Vitex negundo. Plans include extraction of the active ingredients of Chinchona.

Biofarm Drug Factory (Romania)	Short-term experts, on-the-job training, group training and consultancy in vegetal and opotherapic extraction. Products already marketed include a natural chloretic diuretic, an antiseptic/antipruritic for internal and external use, an anti-inflammatory hormone rebalancer and an anti-inflammatory healing spray.
Chemical and Pharmaceutical Research Institute (Romania)	Short-term experts, on-the-job training, group training, consultancy and research services in: production of medicines by synthesis and biosynthesis, processing of medicinal and aromatic herbs, analysis of raw materials and final products, and pharmacological testing. Active principles have been isolated from Atropa belladonna, Papaver somniferum, Sarothamnus scoparius, Sephora japonica, Datura inexia, Tagetes petula, Digitalis lanata, Claviceps purpurea and Colchicum autumnale. Specifical technologies give pure substances or totals of active principles from Pentasidos hybridus, Berberis vulgaria, Vaccinum imntillus. Commercial products containing vegetal active principles include cardiotonic substances, sedatives, analgesics, antispastics, anti-coughing medicines, antacids, blood circulation promotors, anti-inflammatory medicines and hepaprotectives.
Ceylon Institute of Scientific Industrial Research (Sri Lanka)	Short-term experts in essential oils, rubber technology (rubber seed oil) and medicinal plants; on-the-job training in essential oils, instrumental analysis and medicinal plants; group training in essential oils and instrumentation; and consultancy and research services in essential oils, medicinal plants and rubber technology. Sri Lanka has unexploited sources of Terminalia chebula and Phyllanthus embelica, research results on propation, collection and drying of Cartharanthus roseus, Gloriosa superba, Solarium xanthocarpus and Cassia angustifolia (Senna). Plants and cultivation information are available on Withania somnifera, Piper longum, Woodfordia fracticosa, Plumbago indica and others. CISIR has developed methods for initial processing of C. roseus and G. superba.
Anadolu University Medicinal Plants Research Centre (Turkey)	Short-term experts, on-the-job training, group training, consultancy and research services in: distillation and fractionation of essential oils, solid liquid extractions for medicinal and aromatic plants, use of chromatographic and other analytical techniques and equipment, and biological screening. Data bases provide information in English on indigenous plants in Turkey and on published scientific work on plants in Europe. The Centre regularly organizes a group training programme for selected participants from developing countries.

	Hand-on training covers: basic and advanced phytochemical techniques, quality control spectroscopy, chromatography, other analytical techniques, pilot plant processing. Collaborative or individually- sponsored R and D studies may include the following: determination of the flora or a region or country, ethnopharmaceology, trouble-shooting in phytochemical industries, diagnostic studies and rehabilitation of ailing phytochemical or pharmaceutical units, establishment of phytochemical plants, and pilot or industrial scale processing of medicinal and aromatic plants. The Centre will also prepare project proposals and feasibility studies in the field of industrial utilization of medicinal and aromatic plants for submission to funding agencies.
Traditional Medicine Research Institute (United Republic of Tanzania)	Tanzania is a potential resource for medicinal plants, either to be processed and exploited locally or harvested for export. Eleven species are under cultivation: Althea rosea, Anethum graveolens, Calendula officinalis, Cynara scolymus Silybum marianum, Digitalis lanata, Foeniculum vulgare, Hyoscyamus nauticus, Matricara chamomilla, Mentha piperita, Saponaria officinalis, Thymus vulgaris. Seven are used in folk medicine but require therapeutic testing: Achyranthes aspera, Adansonia digitata, Alchornes cordifolia, Anacardium occidentale, Annona muricata, Areca catechu, Asparagus recemosus. Eleven are known to have promising clinical properties and are already used in traditional medical therapy: Anacardium occidentale, Centalla asiatica, Crossopterix febrifuga, Cucurbita maxima, Khaya senegalensis, Nitragyna sp., Phytolacea dodecandra, Punica granatum, Securidaca longipedunculata, Securinega virosa, Zizyphus micronata. A further 18 plants used in folk medicine are beleived to be able to substitute for products recognized in international pharmacoepiae. A list of 27 plants identified in international pharmacoepiae grow in sufficient quantities to harvest.

Annex IV

Results of Bilateral Discussions of Co-operation Projects

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
Guatemala				
Faculty of Chemistry and Pharmacy, University of San Carlos of Guatemala	China	SPAC	Study tour	The plant medicines in Guatemala is at preliminary development stage. The pilot plant provided by Germany through UNIDO technical assistance will be put into operation in November 1990. However, many doctors in Guatemala do not believe in plant medicines. They should have some exposure to Chinese experiences. It is necessary to organize 2-3 doctors to visit China's various institutions for a period of 2 - 3 months.
Faculty of Chemistry and Pharmacy	China	SPAC	Expert service	There is no regulation on the use of plant medicine in Guatemala. The Guatemalan Government wants to formulate such regulation. A Chinese expert is needed to provide advice in formulating such regulation.
Faculty of Chemistry and Pharmacy	China	TIPR	Training	Guatemala requires TIPR assistance in training of phytochemists or chemists; either 2 experts for 2 months or 3 experts for 1 month.

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
India				
Jogindar Nagar Pharmaceutical Centre, Himachal Pradesh	China	SPIDI	Expert services	The rehabilitation of the Jogindar Nagar Pharmaceutical Centre for herbal medicines is required. The existing plant is obsolete. It can meet only 30% of the requirement of the state for Ayerveda hospitals and dispensaries. An engineering and R&D rehabilitation is expected from Chinese side. It requires 5 experts specialised in agro-technology, factory/equipment design, process engineering, pharmaceutcial chemistry and formulation pharmacy.
Indonesia				
Pt. Jamu SIDO Muncul Semarang, Indonesia	China	SPIDI	Provision of eqipment	The Indonesian side requests the SPIDI to make an offer for a ginger extraction plant with a capacity of 500 kgs/day. Technical proposal or quotation will be provided by the SPIDI.
Directorate General of Drug and Food Control, Ministry of Health	China	SPAC	Training	There are 27 provincial laboratories in Indonesia. In addition, there are 7 referral laboratories and 1 central laboratory in Jakara. Indonesia is interested in having China's assistance in ttraining experts on assessment of plant resources, product process development and quality contrcl. The details will be further provided.

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
Nigeria				
National Institute for Pharmaceutical Research and Development (NIPRD)	China	Shanghai Institute of Pharmaceutical Industry (SIPI)		The NIPRD will send plant material and information to SIPI. After experiments, the NIPRD will send 3 persons to SIPI for 6 weeks to do plant-based formulation, dosage form processing, quality test and to acquaint with drug information services.
NIPRD	China	SIPI	Pilot plant establishment	Establishment of a pilot plant with a capacity of 250 kgs/day for R&D purposes.
NIPRD	China	Tianjin Institute of Pharmaceutical Research (TIPR)	Training	Training in phytochemistry, pilot plant processing technique, agro-technology for 3 - 6 months.
NIPRD	China	SPAC	Study tour	Study tours of Nigerian experts to various plant-based manufacturers and institutions in China to acquire experience and technology.
NIPRD	China	SPAC	Joint research programme	Taking into account China's expertise, NIPRD proposes a joint research programme with Chinese institutions, particularly with TIPR. Such programme will cover agroculture, phytochemistry and some other fields.

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
Pakistan				
Pakistan Council of Scientific Industrial Research (POSIR)	China	China Pharmaceutical University, Nanjin	Research	Pakistan needs the following assistance: i) assistance in medicinal plants breeding, cultivation, agro-technology; ii) tissue culture of medicinal plants; iii) bio-assay and pharmacology of medicinal plants. The Chinese experts will work in PCSIR laboratories with respect to plants propogation and biological evaluation.
Philippines				
Cotabato Regional Hospital, Philippines	China	Shenyang College of Pharmacy	Expert service and training	Philippines need co-operation in the following fields: i) general investigation of medicinal plants resources; ii) experts advice on production, quality control and phytochemistry; personnel training in research and development of plants medicines. The Chinese experts will work with their Philippine counterparts in plant-based research and manufacturing activities.
Romania				
Medicinal Plants Processing Factory (MPPF)	China	SPAC	Exchange of products and joint research	The MPPF produces the following products: anhirol, adenostop, romazula, hiramnitan-spray, for which MPPF would like to exchange with the Chinese products. In addition, MPPF would like to obtain Chinese assistance in producing anti-rheumatic and anti-inflammatory drugs or carry on joint research work with their Chinese counterparts.

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
Medicinal Plants Institute of Pharmaceutical Research (MPIPR)	China	SIPI	Expert services	The pilot plant for extraction for supercritical carbon dioxide is being installed. The plant was made in Romania with the exception of compressor which is imported from Germany. The MPIPR requires a Chinese specialist to go to Romania to help check the plant an improve the design if necessary. Then 2 Romanian experts will work in the Chinese laboratory for practice.
MPIPR	China	SIPI	Joint research	MPIPR would like to undertake a joint research with the Chinese counterparts in production of imuno-modulator (polysacharides) and oenothera biennis.
MPIPR	China	SPAC	Joint production	MPIPR would like to have a joint production in anti-ceptive drugs (synthetic or natural). This could be in the form of setting-up a production unit in Romania.

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
Sri Lanka				
Ceylon Institute of Scientific and Industrial Research (CISIR)	China	SPAC	Supply of plant species, information and training on plant cultivation	CISIR would like to obtain some plant species from its Chinese counterparts and the information on the cultivation, post harvest practices and training on modern cultivation. The required plant species include: kaepferia galange, plumbago indice, piper longura, plumbago indice, embelica ribes, picrorhice karrooa, woodfarchia franchicosc, wilharia somnifera, commiphorta mental, nigella sativa, trachgspernum roxburghianum, heridesmus indices, phaseolun adenasthus, aporosa cardiospernus, erythiroxylun nonogyrini.
CISIR	China	SPIDI	Inquiry on equipment prices	The CISIR requests the SPIDI to provide prices of powdering, filtering, tabletting, drying, washing and bottling machines. The prices should be made on favourable terms.
CISIR	China	TIPR	Sample testing	CISIR will cooperate with TIPR in: i) long-term toxicity study and varification for claims of traditional remedies; ii) pharmacological screening of medicinal plants studies by phytochemists. The sample will be sent to China for testing.

Proposer or Main Beneficiary	Country of Counterpart	Counterpart Organization	Type of Co-operation	Project Description
Turkey				
TBAM Medicinal Plants Research Center	China	SIPI	Expert service	2 Chinese experts to design process equipment and upgrading process technology for 3 months in Turkey. Detailed requirements for equipment design and honorarium will be provided by the project sponsor.
United Republic of Tanzania				
Traditional Medicine Research Unit, Ministry of Health	China	College of Traditional Chinese Pharmacy, China Pharmaceutical University, Nanjing	Expert service	To conduct the economic mapping of medicinal flora available in Tanzania. This would require 1 - 2 years expert services.
Traditional Medicine Research Unit	China	SIPI	Expert service	Tanzania has got a pilot plant under UNIDO technical assistance with a capacity of 150 litres, which needs expansion and drying facilities. It requires a Chinese expert to look into the needs on additional equipment for processing local medicinal plants.
Traditional Medicine Research Unit	China	TIPR	Expert service	Tanzania requires 1 botanist, 1 pharmaceutical technologist, 1 organic chemist, 1 pharmacologist for a period of two-years services. Tanzania will provide local expenses and homeward travel.

Annex V
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Annex VI

Formal Papers Presented or Made Available at the Workshop

National papers

Dr. Amarillis Saravia	Situation of the Phytopharmaceutical Industry in Guatemala
J.P. Negi	Status of Herbal and Aromatic Based Industry in India with Special Reference to Western Himalayan Region
Dr. Djoko Hargono	Development of Herbal Medicines in Indonesia
R. Kumara Singham	Country Paper - Malaysia
Prof. C.O.N. Wambebe	Industrial Utilisation of Medicinal Plants: The Nigerian Case
S. Fazal Hussain	Status of Medicinal Plants Based Industries in Pakistan
E.T. de la Fuente M.D.	The Pharmaceutical Industry in the Philippines
Ion Minea	Aspects of Development of Pharmaceutical Industry in Romania Based on Medicinal and Aromatic Plants
Dr. L.S.R. Arambewela	The Country Paper of Sri Lanka
Prof. Dr. K.H.C. Baser/ Dr. Y. Yazan	Status of Pharmaceutical Industry in Turkey
E.N. Mshiu	Pharmaceutical Industry and Drug Position in Tanzania

Background papers (UNIDO Secretariat)

ECDC and TCDC: UNIDO Programmes in Support of Enterprise and Institution Co-operation in the Field of Plant-Based Pharmaceuticals

Issues in the Industrial Development of Plant-Based Pharmaceuticals in Developing Countries

Traditional Pharmacopoeias and the Technology Connection (A paper describing the UNIDO programmes in the sub-sector: Industrial Utilisation of Medicinal Plants)